TOCKLAI EXPERIMENTAL STATION
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ANNUAL SCIENTIFIC REPORT

1970-71

TEA RESEARCH ASSOCIATION, CALCUTTA

Front Cover : *Delegates attending the Joint Area Scientific Committee meeting, inspecting some low tipped young tea, planted 12 months previously at Dirok T. E.*

TEA RESEARCH ASSOCIATION

Annual Scientific Report

(1st April 1970 to 31st March 1971)

Published by
TOCKLAI EXPERIMENTAL STATION
JORHAT-8, ASSAM, INDIA
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Director's Report

(1st April, 1970 to 31st March, 1971)

ORGANISATION

On the 31st March 1971, the Senior Staff consisted of :-

Directorate :

Director
S. K. Dutta, B.Sc. Hons. (Bom), B.Sc. (Wales)

Administrative & Finance Controller
M. K. Choudhuri, B.Com. (Cal), A.C.A.

Accounts :

Accounts Officer
S. Mazumdar, B.Com. (Cal), A.C.A.

Maintenance :

Station Engineer
G. B. Singh, A.M.I.S.E.

Medical :

Resident Medical Officer
Dr. (Major) S. W. Rohman, M. B. B. S.

Library & Publications :

In-Charge
J. N. Sharma, M.A.

Soils & Meteorology Department :

Soil Scientist
S. K. Dey, B.Sc. (Cal), Assoc. I.A.R.I.

Soil Physicist
M. S. Rao, M.Sc., Ph.D.

Senior Scientific Assistants
N. G. Bhattacharyya, B.Sc.
A. K. Sengupta, B.Sc.

Botany Department :

Senior Botanist
D. N. Barua, B.Sc. (Cal), Ph.D. (Cantab.)

Plant Physiologist
W. Hadfield, B.Sc. Hon (Liv)

Plant Breeder
H. P. Bezbaruah, M.Sc. (Gau)

Senior Scientific Assistants
K. N. Dutta
B. N. Gogoi, B.Sc.

Agriculture Department :

Agronomist
F. Rahman, M.Sc. Ag., (Bihar), Ph.D. (I. A. R. I.), New Delhi

Second Agronomist
R. N. Roy, M.Sc., Ph.D. (I.A.R.I.) New Delhi

Senior Scientific Assistant
H. N. Sarma, B.Sc.

Entomology Department :

Entomologist
B. Banerjee, M.Sc., (Cal), M.S. (S. Illin), Ph.D. (London), F.A.Z., F.R.E.S. (London).

Senior Scientific Assistant
N. S. Sengupta, B.Sc.

Mycology Department :

Mycologist
G. Satyanarayana, B.Sc. Hons., (Andhra), Ph.D. (Mad), F.B.S.

Pesticide Department :

Pesticide Testing Officer
T. D. Mukerjea, B.Sc. (Alhd), Ph.D. (London), Assoc. I.A.R.I.

Biochemistry Department :

In-Charge
S. Chakraborty, M.Sc., Ph.D. (Cal)

Manufacturing Advisory & Tea Tasting Department :
Manufacturing Adviser & Tea Taster
R. Choudhury, B.Sc. (Cal)

Second Tea Taster
R. P. Basu

Engineering Development Department :
Senior Research Engineer
D. N. Borbora, B.Sc. Mining (Banaras), M.Sc. Mech. Eng. (London), D.I.C. M. I. Ag. R. E.

Second Research Engineer
T. C. Barua, B.Sc. Hons. (Gau), B.Sc. Mech. Eng. (Banaras) M.Sc. Mech. Eng.(Manchest).

Senior Assistant
P. Morera

Statistics Department :
Statistician
A. K. Biswas, M.Sc. (Gau)

Advisory Department :
Senior Advisory Officer *Assam*
P. C. Sharma, M.Sc. (Banaras), Ph.D. (London), F.L.S.

Advisory Officer—*South Bank*
B. C. Barbora, B. Sc.Ag., M.Sc. Agronomy, (I.A.R.I.) New Delhi
J. Chakravartee, M.Sc.Ag. (Gau)

Advisory Officer—*North Bank*
H. Mitra, B.Sc. (Cal)

Advisory Officer *Cachar*
T. K. Ghosh, B. Sc.Ag. (Pat), Ph. D. (Cornell) Assoc. I.A.R.I.

Chief Advisory Officer—*West Bengal*
W. J. Grice, M.A. Dip. Ag. (Cantab)

Advisory Officer—*Dooars*
S. Basu, B. Sc.Ag. Hons.(Delhi), Assoc.I.A.R.I.

Advisory Officer—*Darjeeling* and *Terai*
S. K. Sarkar, B. Sc. (Cal), B. Sc.Ag. (Banaras)

West Bengal Experimental Station: Mal. :
N. B. Chanda, M.Sc. (Dac), Ph.D. (Edin)

SENIOR STAFF MATTERS

(a) **Appointment:** Dr. R. N. Roy, joined on 1. 3. 70 as the 2nd Agronomist.

Dr. M. S. Rao joined on 2. 3. 70 as the Soil Physicist.

Mr. S. K. Dutta, the Deputy Director was appointed as Director from 1st March, 1971.

Dr. P. C. Sharma was appointed Senior Advisory Officer, Assam on 1st March, 1971

(b) **Retirement:** Mr. D. H. Laycock, Director, retired from the Association's service on the 28th Feb. '71. Dr. T. D. Mukerjea, Pesticide Testing Officer, retired from the Association's Service on 31st March, 1971.

TRAINEE

Ten trainees completed the One year Tea Culture Course during the year under report. Besides Member estate employees, there were nominees from Mauritius, Sikkim, Nainital district of U. P. and Tea Board.

In addition, ten employees from Member estates completed training in Vegetative Propagation.

LECTURE COURSES

The following Lecture Courses were held during the year :—

1. **Factory Management Course (1970)**
1st Course: 26th—29th October—31 planters attended.
2nd Course: 2nd- 5th November-31 planters attended

2. **Surveying & Drainage Course (1970)**
1st Course: 9th-14th November -24 planters attended
2nd Course : 23rd-27th November -20 planters attended.
3rd Course: 30th November-4th December—25 planters attended.
4th Course: 7th-11th December—25 planters attended.

VISITORS

Some of the Visitors in addition to local planters who are listed below :-

P. K. Kanoria--Vice Chairman, T. R. A., Calcutta
K. Meindertsma---Amsterdam
L. Latham--Harrisons and Crossfield, Cochin
A. N. Norris ,, ,, ,,
E. P. W. Da Costa—The Marketing Research Corporation of India, New Delhi
D. W. Beal--F. A. O., Rome
R. W. Moss- World Bank, New Delhi
R. N. Harris—F. A. O., Rome
A. R. Frampton—New Zealand
G. R. Onaba- Uganda Tea Growers Crop
M. Tavana—Iran
N. Nia—Iran
P. T. Mirie--Ministry of Agriculture, Nairobi
H. R. Shekilango—Tea Extension Officer, Tanzania
D. S. Mtenga—Tanzania
R. W. Bastin—F. A. O., Rome
J. Douglas--Rockfeller Foundation, USA, New Delhi
Dr. Banerjee—I.C.A.R., New Delhi
L. Ramdin—Mauritius
Dr. I. C. Mahapatra--I.A.R.I., New Delhi
Dr. D. M. Leenwrik—Ford foundation, New Delhi
Prof. J. R. Seshadri—University of Delhi
D. S. Mulla—Bombay
M. M. Sharma—Bombay
Kanwar Amrit Lal--I. T. A, New Delhi
Ridgeby Foster--London
David R. Scott—G. Harison & Co. London
Charles F. Pontin—New York, USA
H. Ferguson--James Finlay & Co. Ltd., Glasgow
I. Hakjmi—Iran

Advisory Department—Assam

Extension Services

Increasing demand continued for advisory visits both from Agency houses and proprietary estates. Specialist officers also paid visits to the estates whenever necessary. Recommendations given were in general followed with good results.

Besides routine problems, discussions during advisory visits concentrated around land planning and drainage, chemical weed control, potash manuring, foliar spraying, bringing up young tea, pruning, plucking and cleft grafting.

Four lecture courses on Surveying and Drainage were held during the year. These courses greatly benefitted the planters as seen from the improved drainage work done by the planters after attending the courses. Two courses on Agricultural Chemicals were conducted by the Department during the year. Monthly bulletins on Pests and Diseases were published by the North Bank, South Bank and Cachar Advisory Branches from February to October.

An ill kept main drain

Continued interest was shown on the Area Scientific Committees and group discussions (managers' meetings) in all the three districts.

The districtwise advisory visits paid were as follows :

Area	Total No. of visits	No. of estates visited	Visits to experiments
South Bank	219	153	25
North Bank	181	71	9
Cachar	74	27	23

Crop Outturn

In general, Assam produced more crop compared to the previous year. However, North Lakhimpur and Moran sub-areas of North Bank and South Bank respectively, obtained less yield during the year compared to the 1969-70 season. Some estates in Chutla Bheel and Hailakandi sub-areas of Cachar, recorded less yield due to severe hail damage in the early part of the season.

Field Management Practices

(a) **Land planning and drainage :** After attending lecture courses on Surveying and Drainage at Tocklai, planters became more drainage conscious than before and were more keen on scientific tackling of the drainage problem.

Some estates were given advice on drainage pattern for replanted and extension areas on the basis of topography and a few others got good results by modifying and renovating their old drainage systems. Emphasis was also laid on the cleaning, deepening and regrading of the existing drains. The capacity of the sub-main or main drains in most estates still remained much below the optimum. For efficient disposal of drainage water it was emphasised during advisory visits that the drain size and shape should be on the basis of catchment areas.

Difficulties were encountered by a number of estates as the main drains which often run through land not belonging to the estate, were bunded for fishing or paddy cultivation by labourers or outsiders, which caused back flow of drainage water; the efficiency of an otherwise good drainage system was thereby reduced.

A stepped sub-main drain

In Cachar good results were obtained by isolating clay flats on "bheel" areas by providing perimeter drains at the foot of the teelas. On "teela" slopes construction of contour drains and bunds was done by a few estates, although many of these drains were not big enough in size and depth. Accordingly, for proper drainage estates were advised on the size and spacing of contour drains depending on the soil type, slope, rainfall and its intensity and distribution. Construction of graded contour drains and contour planting following the master row system, were advised in a few estates.

To check erosion and run-off, growing of *Eragrostis curvula* (weeping love grass) was suggested on the contour bunds in Cachar.

(b) **Pruning Cycle**

A three-year pruning cycle of Prune-deep skiff-medium skiff has been followed by majority of the estates. Some estates have preferred light or level-off skiffing to medium skiffing in the cycle with a view to obtaining more early season as well as total crop. A number of estates have followed a four year cycle of Prune-deep skiff-medium skiff and medium, light or level-off skiffing in the fourth year. There are, however, a few estates following a two year cycle of Prune-deep skiff to obtain better quality tea; on the other hand, a few others kept certain percentages of tea "unpruned". One estate in the North Bank was strictly on an annual prune for fear of losing quality.

A newly widened, deepened and regraded sub-main drain. Size calculated on catchment basis, at Hunwal T. E.

In some estates, the expected yield was not obtained from medium skiffed tea. This was mainly due to more banjhi shoots building up in the top hamper, as a result of high frames of the bushes, skiffing at the wrong time and level, liberal tipping and plucking. Tipping measures of 5 cm to light leaf Assam kind and vigorous young tea, and shorter measures of 3-4 cm for teas having shorter internodes (Manipuri or hybrid kind of tea) gave satisfactory results in medium skiffing. Deep skiffed tea was plucked at 7.5 cm - 10 cm above the level of skiffing depending on the kind of tea.

Height reduction pruning has become popular particularly in the North Bank to remove knotty, dead and diseased branches from high frames. A few estates in Upper Assam resorted to heavy pruning at 15-30 cm ground measure in order to rejuvenate old tea by removing diseased wood from hide bound frames.

The standard of pruning skiffing in many estates was far from satisfactory. The Advisory officers during their tours, demonstrated proper method of pruning skiffing by giving samples in the estates, and whosoever had listened to this advice and improved the standard of pruning skiffing, was benefitted in terms of crop.

Low tipped young tea 12 months after planting, clone TV 9 Note : no green crop but *Indigofera teysmanii* planted at closer intervals

(c) **Shade :** For extension or replanted tea, advice was given to establish temporary shade of *Indigofera teysmanii* at closer spacing of 1.5 m - 2.5 m apart prior to replanting tea, in preference to green cropping. As these shade trees with age, grow in height and spread, they are gradually thinned out and permanent shade of *Albizzia odoratissima*, *Albizzia lebbek*, *Derris robusta*, *Dalbergia sericea* etc. are planted out. *Acacia lenticularis* which has recently been introduced is gaining popularity as a permanent shade. Growing of *Albizzia chinensis*, *Albizzia procera* and *Albizzia lucida* has been discouraged due to high incidence of canker in these species.

In a few estates of the North Bank, *Indigofera teysmanii* was found to be attacked by looper caterpillar and *Leucaena glauca* was suggested instead.

It was generally noticed that young shade trees were not being properly looked after. The Advisory Officers, therefore, stressed the necessity of making proper planting pits, manuring at the time of and subsequent to planting, and regular spraying against pests and diseases.

(d) **Cultivation and Weed control:** Chemical weed control became increasingly popular during the last three to four years. Planters had been advised to fill up depressions around the collar of the bushes and level the ground in the cold weather prior to weedicide treatment. The common weedicides used were Gramoxone, 2,4-D, Dalapon, Dalapon + 2, 4-D, and Karmex + Gramoxone cocktail. It was found that continued use of Gramoxone had resulted in the emergence of certain weed species like *Polygonum chinense*. This is a hardy creeper and occurs in patches. 2,4-D was advised @ 1.5 - 2.0 kg (a.i) / ha to be applied as spot spraying only, after pulling out the creeper if it had climbed onto the tea bushes.

Manual cultivation was discouraged except where it was necessary to fill up depressions and level the ground. Many estates found it difficult to keep up their chemical weed control either due to late or non-availability of Gramoxone. Under such circumstances, planters were suggested to do sickling and spray 2, 4-D @ 0.75 kg (a.i)/ha to control broad leaved weeds between rounds of sickling.

Estates with chemical weed control found that labourers engaged in manual cultivation could be released for other important operations like plucking during peak season. With the use of chemicals, young teas were able to be kept cleaner than before.

(e) **Manuring :** The manuring recommendation for mature tea for the South Bank was modified in 1970. Besides the usual dose of nitrogen, 40 kg potash per hectare is recommended every year, and phosphate @ 20 kg h/a every third year. Both phosphate and potash were recommended as replacement of the amount removed by the crop. However, on soils with low potash status, good response in terms of crop was obtained in a number of estates in the Assam Valley as well as in Cachar with remedial dressings of potash @ 100 kg or more per hectare. Besides, remedial dressings of potash improved the general condition of the tea. These encouraging results have led many planters to start potash manuring in 1971 in a big way, particularly in the South Bank. A number of potash experiments are consequently planned for 1971 in all the three districts in cooperation with the Soil Scientist to study the response of potash under different soil and climatic conditions.

Six months old Guatemala grass. For rehabilitation of soil after uprooting

Phosphatic fertilisers with little or no calcium content such as Triple Superphosphate, di and mono-ammonium phosphate were recommended in place of single superphosphate.

(f) **Plucking :** The standard of plucking in general, improved in many estates but in a few others, plucking of medium, light, level-off skiffed and unprunned tea was not satisfactory.

Mulching of four months old young tea

(g) **Mulching :** The importance of mulching during the first three to four years from planting has not yet been realised by many planters. It was found in a few estates that young tea areas were left exposed to the weather conditions, even though enough Guatemala grass was available nearby. The Advisory officers stressed the importance of mulching young tea 7-10 cm thick and renewing the mulches as and when necessary, till the ground was completely covered by the tea.

When slowly decomposing materials like paddy husk and straw were used, it was suggested to broadcast sulphate of ammonia @ 20 kg N ha for quick decomposition of the mulch material and stop temporary nitrogen starvation in the soil.

Estates were advised from time to time to grow any suitable crop like Guatemala or Pusa Giant Hybrid Napier grass on road sides, hulla edges and on garden waste lands to supply mulching material.

(h) **Mr. S. K. Dutta's new system of bringing up young tea :** Excellent results were obtained in some estates by following this method. Besides clones, this was tried in some estates on vigorous seedlings with good results. However, it is

unfortunate that a few estates had tried the method on weak or old plants without following the instructions properly and the results were even worse than the conventional method of bringing up young tea. Planters were cautioned not to adopt this method indiscriminately.

Low tipped young tea at Dessoie T. E. in the second year after planting. Clone Teenali 17

(i) **Other Field Management Practices :** The technique of cleft grafting was demonstrated on a number of estates. Advice was also sought on vegetative propagation and seed nursery, spacing of tea, green crops and cover crops, seed and clonal bari.

Pest and Disease Control

Red spider continued to be the major pest in the South Bank and Cachar while in the North Bank, its incidence was lower than in the previous year. Estates doing prophylactic spraying were able to control the mite to a considerable extent. Scarlet mite appeared in some estates in all the three regions, particularly on young and unpruned teas. The incidence of pink and purple mites was less compared to the previous year. In general, the degree of mite control depended on the efficiency of spraying and the acaricides used. Tedion, Kelthane, Morocide, Trithion and Ethion were widely used with good results.

Looper caterpillar was reported by a few estates in the South Bank, and it posed a threat to several estates in the Borsola and Tezpur sub areas in the North Bank, where besides tea, the pest had damaged *Indigofera teysmanii* shade trees. Bunch caterpillar caused severe damage in a few estates in the South Bank. Bunch and sandwich caterpillars were also reported by some estates in Cachar. Aphids, thrips, flushworms, helopeltis and green fly appeared as minor pests in all the three districts. Greenfly attack has been found to be increasing in certain areas of North Bank.

Attack of *Agrilus bessoni* was reported mainly on *Albizzia chinensis*, *Albizzia procera*, *Albizzia lucida*, *Albizzia lebbek* and *Albizzia odoratissima*. Leaf eating insects were most prevalent on *Albizzia odoratissima* and to a lesser extent on *Derris robusta*, *Albizzia lucida*, *Albizzia chinensis*, *Albizzia lebbek* and *Indigofera teysmanii* . Membracids attacking shade trees appeared as a minor pest in all the three districts. Scale insects were increasing in the North Bank.

Red rust and Black rot continued as the important diseases while blister blight was reported by a few estates in Cachar. Better field management practices and potash manuring reduced the severity of red rust infestation in many eastates. Copper fungicides were advised to be sprayed twice at fortnightly intervals from April May when the fruiting bodies of the algae are seen on the tea bushes and preferably two more rounds at monthly intervals in June / July.

Black rot appeared in a severe form in a number of estates in the North Bank. The disease was controlled to a great extent in some estates by spraying copper fungicides (prophylactic and palliative) and by thinning out shade where it was too heavy.

Short supply of insecticides and fungicides affected the timely control of pests and diseases in the North Bank.

Extension, Uprooting and Replanting

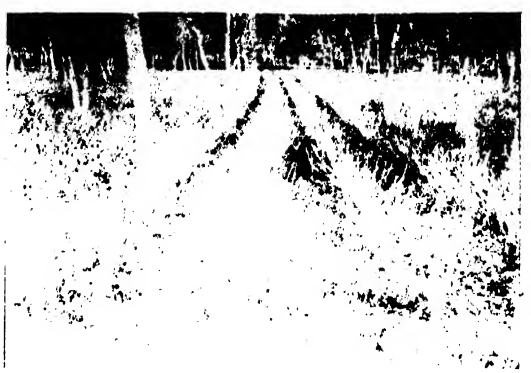
The new Land Ceiling Act of the Government of Assam has caused great concern to many estates having large area of cultivable fallow land and these estates are, therefore, bringing more area under extension planting. Uprooting and replanting was the practice with estates having little or no land for extension. Rehabilitation of land for a minimum period of nine months as suggested under the Tea Board Replanting Subsidy Scheme could not be considered adequate because in most estates the rehabilitation crop did not grow well. It was stressed that estates should not go by the time factor but should aim at satisfactory growth of the rehabilitation crop. Planters were advised to prepare, level up and sub-soil the uprooted areas and provide a suitable drainage system according to the topography, before sowing the rehabilitation crop.

Closer spacing either in single hedge or in regular or staggered double hedge was advised both for replanted as well as for extension areas for planting a minimum of 11111 bushes per hectare.

Agricultural Machinery

The indigenously manufactured engine that is being used in majority of the power sprayers needs constant attention. Many planters complained about the efficiency of these machines. Jawan, Motoblo, Aspee Bolo, Autoblo, and Micronette were the makes commonly used by the estates. Many estates were continuing with Knapsack type of hand operated sprayers while Aspee Back pack was popular for spraying weedicides. It was felt by many planters that facilities for repairing power sprayers and obtaining spare parts were inadequate in the tea districts.

Road side being used for growing mulching material, (Guatemala grass)



Young tea pruned at the end of the 3rd year of low tipping method at Ghillidary T. E.

Meetings

Area Scientific Committee : There are three Area Scientific Committees on the South Bank, two on the North Bank and one in Cachar. During the year a total of 17 meetings were held as under:

South Bank,	East	— 2
,, ,,	Central	— 1
,, ,,	West	— 2
North Bank,	East	— 4
	West	— 4
Cachar		— 3

A joint Area Scientific Committee meeting was held in Upper Assam from 1st to 3rd March, 1971. Delegates from different scientific committees and about 50 planters attended the meeting. Delegates showed keen interest in young tea management, including pegging and low tipping, rejuvenation of old tea by heavy pruning and in an estate planted entirely with clones.

Advisory Department – West Bengal

GENERAL

The West Bengal Advisory Department consists of the Head Quarters office and plots at Nagrakata where the Chief Advisory Officer, West Bengal, and Advisory Officer, Dooars, reside, and an office in Darjeeling where the Advisory Officer, Darjeeling and Terai, resides, and a Soil Testing laboratory at Mal where Dr. N. B. Chanda resides. There were no changes in the senior staff during the year. The Advisory Officer, Dooars, was away for the first four months of the period under review in the U. K. on study leave.

During the year the Advisory Officers in the Dooars and Darjeeling concentrated on routine Advisory touring of Member estates. The Chief Advisory Officer, West Bengal, was kept occupied with the supervision and conduct of field experiments and Dr. N. B. Chanda looked after miniature manufacture of experimental samples in the Dooars.

It was a great disappointment that the Second Tea Taster resigned before taking up residence in the Dooars.

VISITS

The table below gives the break down of the visits made by the Advisory Officers in each district.

District	No. of visits	No. of Members visited	No. of member estates in the District
Dooars	113	53	92
Darjeeling including Sikkim	80	46	51
Terai	35	17	18
Total	228	116	161

There was a slight increase in the number of visits to estates in Darjeeling and the Terai and a reduction in the Dooars which is due to the Advisory Officer, Dooars, being away for four months on study leave.

In addition of the visits detailed above, the Chief Advisory Officer visited 9 estates in South India during a two week tour in September. He also accompanied the Director on his two visits to West Bengal during the year and Dr. M. S. Rao to twelve estates in the Dooars. He also paid 58 visits to garden experiments and four visits to the Clonal Proving Station in Darjeeling.

It is satisfying to be able to record that our advice has been generally followed and the problem of implementation due to labour unrest has been nothing like as bad in the year under review as it was the previous year.

In general all districts were affected by the drought early in 1970; however, recovery was good and except for a set back in Darjeeling in June when the weather was very cloudy and wet, all areas had a reasonable year and were generally ahead over the previous season.

The principal points arising from advisory work are discussed briefly below :

(i) Soil Management

(a) **Land Planning :** It is a pleasure to report that during the year two estates on the plains have, with the co-operation of the Department, organised replanted and extension areas using modern methods of land planning. Very many more requests for advice on this aspect were received from other Members and it is anticipated that land planning will be a common topic for discussion during advisory visits in the future.

No estate has yet had a complete level survey of the whole estate and planning to date has been confined to the old section boundaries. This may be due to the fact that there is a dearth of good surveyors in the tea districts of West Bengal and a reluctance to plan ahead under the trying labour conditions. The Department will however continue to stress the importance of advance planning.

(b) **Drainage :** This topic can be more conveniently discussed in two parts : (i) already established mature tea and (ii) replanted and extension area. For both, a most essential preliminary is a good level survey and this is not always available. In addition, the height of the water table during the monsoon months must also be known.

Culverts on collector drains – a continual hazard to efficient drainage (Dooars)

In already established mature tea, a compromise of straight drains roughly parallel to the contours has to be accepted. Generally the finding of good outfalls is not a serious problem in the plains areas, but in view of the heavy rainfall, culverts on collector and main drains are a continual hazard to efficient drainage and this topic has featured in a number of advisory reports.

We have continued to advise the planning and laying out of the correct drainage system in uprooted and extension areas before the planting of tea. In spite of considerable publicity in this respect, we still find young tea being planted before the drains have been dug. It has been pointed out that efficient draining is mainly a matter of good advance planning and must be considered at the same time as topographical planning (see above).

(c) **Mulching :** The beneficial effects of mulching are now quite readily understood and appreciated but the cost of mulching has generally been found to be prohibitive. However, estates have been urged to utilise all vacant areas by planting Guatemala and Pusa Giant Hybrid Napier grasses, and the efforts made by some estates in this direction are commendable.

It is hoped that with more extensive use of herbicides, more labour will be available for mulching in the near future.

(d) **Cultivation and Weed Control :** It has been pointed out that once herbicides are introduced, these should be used continuously to get an economic control of weeds, and for this reason it has been advised to fix a target for chemical weed control with the object of controlling weeds effectively in the target area.

Due to very heavy rainfall in the Dooars and Terai during the period mid June to mid September, the application of weedicides during this period becomes difficult and estates were advised to complete at least two rounds by the middle of June. We advised that Gramoxone is sprayed on clear days in the monsoon months and this be followed by spraying translocated herbicides in the early autumn period, to ensure that the weeds do not flower and set seed. Excellent control of Mikania was achieved by spraying 2,4-D in the autumn period.

The weedicides that have been most commonly used are 2,4-D, Dalapon and Gramoxone with good results. One estate used the weedicide cocktail of Gramoxone and Karmex and one round kept the area virtually weed free for the whole year.

Simazine as a pre-emergence herbicide continues to be used extensively in V. P. nurseries and, if applied correctly, it will keep the nursery weed-free for at least 2 months.

Where manual cultivation was still in vogue, managers were discouraged from cheeling in January and February.

In Darjeeling the large scale use of weedicides has been discouraged pending the results of our trials on the use of weedicides vis-a-vis soil erosion. (see comments under Experiments).

Preservation of pruning litters in heavy pruned area — Gielle T. E. (Darjeeling)

(ii) **Pruning & Plucking**

(a) **Pruning Cycles :** In the Dooars and Terai a three year pruning cycle of light prune, deep skiff, and medium, light or level skiff continues to be the most popular. Advice has been given on several occasions on suitable four year cycles where labour is available for plucking and useful early rainfall is not unusual. Special cycles for droughty areas such as the South Terai and sandy estates in the Dooars have been advised. We have stressed the fact that no one cycle will meet all the requirements of the large variety of clones and jats now planted, for the frame height and the varying soil and climatic conditions will impose limitations and these *must* be taken into consideration when deciding on a pruning cycle.

There is no doubt that if the frame height is low, the management has a much wider flexibility over the selection of the pruning cycle. Therefore, advice has been given for establishing the frame, height lower in young tea areas and also medium pruning lower than has been the practice in the past.

In Darjeeling, we have advised that the pruning cycle be geared to produce the maximum first and second flush crop, bearing in mind the limitations imposed by the ability of the labour to keep pace with the plucking round.

Labour limitation has resulted in pruning cycles being shortened in a number of estates and on occasions we have considered this unnecessary and have advised that it is better to introduce the heavier skiffs (deep and medium) into the cycle rather than shorten the pruning cycle.

The problem of banjhis between flushes has again featured in advisory reports and we have stressed that the best way of dealing with this problem is to pluck the banjhis by hand. Where this was not possible, even skiffing for the removal of banjhis was also advised.

(b) **Plucking :** Advice on plucking and tipping measures was frequently given and it was stressed that the optimum is intimately connected with the pruning cycle, for unless the correct tipping measure and plucking standard are maintained, which in turn is dictated by the prune or skiff given, the best will not be achieved. It was not often realized that the tipping measures advised, should be used as guide lines only and adjustment to them would be necessary in abnormal climatic conditions.

There was a tendency in some estates for the rise of the table to be unnecessarily excessive. This resulted in a loss of crop and had been a subject for report following advisory tours. In Darjeeling, however, it was more often the rule than the exception for plucking rounds to become longer than desirable. This is a topic that has featured in this report for a number of years and it is gratifying to be able to record that there has been an improvement on this front in the year under review. There is still a lot of room for improvement and we believe that if the correct pruning cycle is followed and severe skiffs are introduced, the problem of plucking rounds becoming out of hand will arise only under exceptional circumstances.

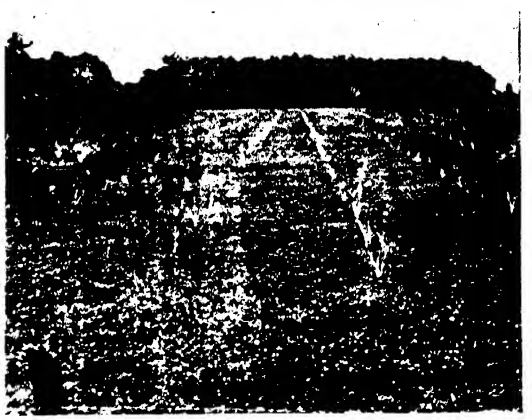
(iii) **Planting**

(a) **Infilling :** It is gratifying to be able to report that on plains estates an infilling programme is now more often the rule and advice on treatment of infills is often a topic for discussion. It has been stressed that to reap the maximum benefit from infilling, only well grown plants of a hardy, vigorous jat or clone should be used. In old square or triangular planted fields, double the number of infills plus one should be planted and adequate maintenance should be given to the young plants to ensure establishment.

Infilling is not common in Darjeeling, but its importance has been realized and estates are programming for infilling in the future by expanding their nursery areas and establishing suitable clonal material.

(b) **Extension :** Extension planting was naturally confined only to those estates where land was available. We have advised extension planting before uprooting and replanting of old areas. However, there was a tendency to extend on land not entirely suitable and our advice under these circumstances was that more profitable use of such land would be to use it for growing suitable mulching crops.

(c) **Replanting :** Uprooting for replanting is common on those estates that do not have land on which to extend. The impetus given to replanting by the Tea Board's replanting subsidy scheme appears to have reached an equilibrium. Estates have been warned that unless an adequate rehabilitation period of at least two growing seasons is given, results from replanting will be unsatisfactory. It should be recorded that not all estates follow a two year rehabilitation period and this is more than likely to be due to the fact that it is not essential under the rules of the subsidy scheme. However, the general tendency is for estates to make a greater effort over rehabilitation than was common in the past.



An uprooted area just planted with Guatemala cuttings—Batabari T. E.

(iv) **Propagation**

(a) **Seed :** Where seed was being used in plains estates the tendency was to use hardy jats and, in accordance with our recommendations, polyclonal Stock 203 is very much in demand as it has now been proved under the conditions prevailing in the Dooars and Terai. In Darjeeling the same tendency was seen and estates were using hardy jats for planting in the lower elevations. In high elevations, no suitable jat was yet available and where planting was done at these elevations we advised the use of proved clonal material.

(b) **Vegetative Propagation :** Routine advice on all aspects of V. P. work was common. Cleft grafting for the rapid multiplication of clonal stock became increasingly popular and became routine on a large number of estates.

It would be safe to say that the majority of the estates in the Dooars and about half in the Terai were in a position to undertake all their planting with clonal material. We have continued to stress the importance of testing clones on estates before

large scale planting of any one clone is undertaken. By and large it was seen that estates were tending to use clones more suited to the environment than they were in the past.

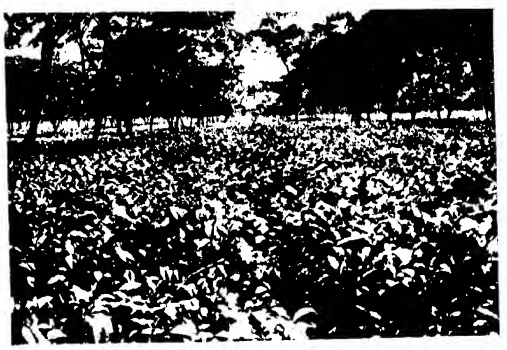
In Darjeeling the picture was one of extremes. Only a very few estates are in a position to plant all clonal material and these estates are going ahead at a very rapid rate. Others are lagging behind and we can think of no valid excuse for this, for suitable clonal material has become more readily available. The sooner these estates appreciate that vegetative propagation of tea is no longer a pastime confined to the Manager's back garden, but a proved commercial proposition, the better for the Industry in that District.

(v) **Fertilizers**

(a) **Nitrogen :** Following the poor year in 1969, the tendency was to economise on fertilizers for the 1970 season and in fact some estates did not apply any fertilizers at all. There was thus a tendency for the nitrogen level to be less than the previous years. When we were asked for advice on this we warned our clients of the damage that occurs to the soil nutritional balance from withdrawing fertilizers for one year, although the harmful effect may not be immediately apparent.

Advice was frequently sought on various aspects of foliar application of urea. This had become routine on some estates in nurseries. Others were using foliar application for boosting up the early crop on light and level skiffed areas.

(b) **Potash :** In view of the encouraging results obtained from high levels of potash in some areas in Assam, some estates in the Dooars tried application of potash in sections which were showing a downward trend in yield. These trials, although not properly laid out, have given indications that a case for high levels of potash in the plains estates in West Bengal does exist and currently we are advising that the rate of potash to apply is based on the available potash in the soil. Large scale garden experiments have been laid out and our aim is to be able to give concrete advice on potash manuring at the start of 1972.



Indigofera teysmanii – well lopped and giving correct shade, (Sannyasithan T. E.—Terai)

Indigofera teysmanii — not lopped and giving heavy shade, (Sannyasithan T. E.—Terai)

(vi) **Shade**

(a) **Green Crop :** Often green crop is intentionally kept *in situ* longer and at a heavy density with a view to suppressing weed growth. It has been pointed out that if weed growth is suppressed by the green crop then the growth and development of the tea is also suppressed and we have strongly advised against this practice.

(b) **Temporary Trees :** *Indigofera teysmanii* remains the most popular temporary shade tree. Its draw back of having a canopy that becomes too heavy unless kept frequently lopped, has been the subject of comment on a large number of occasions.

(c) **Permanent Trees :** The establishment and maintenance of a permanent stand of shade still continues to be an exasperating exercise. We have however continued to stress that if shade trees can be given a good start they are in a better position to resist the onslaught of pests and diseases later.

As a complete paradox to the above paragraph, there are a large number of areas where the permanent trees are large and are over shading the tea. Here we have advised the lopping of branches rather than the removal of trees with the object of obtaining a continuous, high single layer of foliage over the tea. We have recommended that to obtain the optimum shade requirement planting distances should be adjusted.

There has been no change in the species used for permanent shade, but we have continued to advise against the use of *Albizzia chinensis* and *A. odoratissima* in view of their extreme proneness to attack by various pests and diseases, in particular canker.

The above comments apply to plains estates. In Darjeeling shade is not required on hybrid tea at elevations above 600 metres on South and Western aspects and above 500 metres on North and Eastern aspects. Where light leaf *Jats* have been planted, we have advised that shade should be provided upto elevations of 600 metres on the hotter aspects and 700 metres on the cooler.

(vii) **Pests & Diseases**

(a) **Pests & Diseases Bulletin:** The Bulletins continued to be popular, and to give them a wider appeal, they were shortened towards the end of the period under review.

(b) **Red Spider :** Due to the early drought, red spider was not active until March/April in all Districts. There was a sudden flare up of this pest in April and a great deal of damage was done in the months of May and early June. The sudden epidemic attack was the worst seen in recent years. It should however be recorded that where prophylactic and palliative sprayings were well done, red spider was not a menace.

(c) **Other Pests :** Scarlet and purple mites, particularly the former, did more damage in all Districts early in the season. Helopeltis was quite severe in some plains areas during the late rains and autumn. In Darjeeling, thrips did considerable damage to pruned tea where control measures had not been taken. Frequent advice had to be given on the necessity of controlling scale insects whose insidious damage often goes unobserved.

(d) **Diseases:** Advice on control measures of the two most important diseases, red rust and black rot, was frequently sought. Several estates have successfully controlled black rot by reducing shade density, knife cleaning out, and prophylactic and palliative spraying with copper fungicides.

As is usual, blister blight was bad in Darjeeling where control measures were not taken. It is a continual mystery why a more serious attempt is not made by Darjeeling estates to control blister blight for it is one of the easiest diseases to control and when left uncontrolled a considerable loss in crop results.

EXPERIMENTS

1. Experiments and other activities at Nagrakata H.Q.

(i) **General :** The period 1st November 1970 to 31st March 1971 was the driest ever recorded at Nagrakata since the establishment of the meteorological station. While this caused a lot of die back and some deaths in the plots, it gave us the opportunity of assessing the drought resistant properties of a wide range of clones planted in our plots. It was interesting to note that clones planted in the autumn of 1970 which were well mulched, withstood the drought very much better than the same clones planted in 1967 and 1968 and kept unpruned during the drought.

This prolonged drought broke with a very severe hailstorm on the 1st April, 1971. The automatic rainfall recorder registered over three inches of rain in three quarters of an hour and during this time there was a very strong wind accompanied by incessant hail with hail stones slightly smaller than golf balls in size.

The adverse effects of this storm will feature in the 1971/72 Annual Report.

Clonal trial plots at Ging Clonal Proving Station Darjeeling

(ii) **Release of Tocklai Clones and Rehabilitation Grasses**

(a) **Vegetative :** Just under 2,49,000 cuttings of Tocklai release clones were distributed to Member estates in West Bengal. This is a large increase on the previous year when only 85,000 cuttings were distributed.

Just under 800 scions of vegetative clones were released to Member Estates in West Bengal.

(b) **Generative :** Two pairs of generative clones that are used to produce the biclonal stocks 449 and 450, were released for the first time. A total of 8900 cuttings and 870 scions of two of the clones were released. Member estates are already in possession of the other two clones.

490 scions of the 7 clones forming the polyclonal stock 203 were released to one estate that is converting a jat seed bari by grafting.

(c) **Rehabilitation Grasses :** Over 2000 stems of Guatemala Grass and Pusa Giant Hybrid Napier Grass were released to Member estates during the year.

(iii) **Experiments**

(a) **Agricultural Trial 1967/68 :** This trial was planted in 1967 and 1968. The growth, yield and reaction to the Dooars conditions of 15 Tocklai clones, 2 clones from Mal and Stock 203 are being compared. Towards the end of the severe drought, observations on the ability of the clones to withstand drought were taken in the two blocks that had been left unpruned.

The results of these observations were as follows:-

(1) TV1, TV12, TV16 and TV17 had good resistance to drought.

(2) TV4, TV7, TV8 and TV14 had fairly good resistance to drought.

(3) Stock 203, TV9, TV10 and TV11 had fair resistance to drought.

(4) TV2, TV6, TV13 and TV15 had poor to very poor resistance to drought.

Of the two clones from Mal included in this trial one was classified as having fair drought resistance and the other as very poor.

(b) **Observation Plots, Mal Clones :** Yield recording in these plots were continued and in respect of yield upto the end of the 1970 season, 5 clones showed promise. Observations during the drought period from November 1970 to March 1971 indicated that of these 5 clones, one had fairly good resistance to drought, two were fair and two were poor.

Manufacture of all the clones in the observation plots was carried out in the Meenglass Miniature Factory. It was not possible to assess the liquor characters of the different clones due to faulty manufacture. The aim is to assess the liquor characters in 1971 and make final selections of clones showing sufficient promise to warrant further trials.

(c) **Nitrogen Response on Different Clones:** The design of the trial was finalized and a start was made on planting.

(iv) **Quality Testing Scheme**

(a) **1969 Trial :** Routine work on the eight estate clones in this trial continued.

(b) **1970 Trial :** Twelve clones from estates were planted in this trial.

(v) **Nanda Devi Seed Bari (Stock 378)**

The two generative clones were grafted onto stock trees of TV9, TV10 and TV11 in this bari. The success has been good. The plan is to complete the grafting in 1971/72 and it is hoped that sufficient seed will be available for distribution to Darjeeling estates by the end of 1973. This will be one year behind the original schedule caused by the set back received from the successive droughts of 1969/70 and 1970/71, and the fire reported last year.

(vi) **Establishment of Future Release Clones**

Sections of 4 clones tentatively earmarked for future release were grafted twice in 1970. Clone 468/3/13 is showing promise.

2. Clonal Proving Station, Darjeeling

(a) **General :** The plots in the Proving Station were damaged by hail on the 31st March,1971. It is anticipated that this will result in the programme for manufacture being upset particularly for trial A.

(b) **Factory :** The difficulties encountered over electricity were overcome and by the middle of 1970 all samples were manufactured in the miniature factory.

(c) **Trial A. Planted 1967 :** Plot yields were recorded and samples manufactured throughout the season. Three clones namely Bannockburn 157, Phoobsering 312 and Tukdah 145 have yielded sufficiently well and been given good marks for liquor characteristics, particularly in respect of flavour, to warrent them being given an Interim Certificate which was issued at the end of the 1970 season. As several other clones in this trial are showing promise, it is expected that further certificates will be issued at the end of 1971.

(d) **Trial B. Planted 1968 :** Eight clones are under trial of which three Tocklai clones and one estate clone are giving good yields.

(e) **Trial C. Planted 1969 :** Observations on growth were made in this trial.

(f) **Trial D. Planted 1970 :** Six hybrid clones selected at Tocklai were planted in this trial during the year and observations were made on their growth.

There are now 39 clones under trial at the Proving Station and their yields are being compared against the Nanda Devi biclonal standard and cup characters against Nanda Devi and hybrid leaf from a nearby area on Ging T. E.

It is appropriate to record our appreciation of the excellent co-operation received from Ging T.E. over the running of the Proving Station.

3. Field Experiments on Estates

Short and Long term experiments covering a number of projects have been continued on Member estates. A complete list of Advisory Department experiments is given in Appendix A, and a list of experiments being conducted in co-operation with other Departments is given in Appendix B. The number of experiments in different areas is given below.

	Advisory Dept. Experiments	Experiments conducted in co-operation with other Dept.
Dooars	19	19
Terai	3	4
Darjeeling	13	5

MEETINGS

The following annual general meetings were attended:

(i) T. B. I. T. A. by the Chief Advisory Officer, West Bengal, and Advisory Officer, Darjeeling & Terai.

(ii) Dooars B. I. T. A. by the Chief Advisory Officer, West Bengal, and Advisory Officer, Dooars.

(iii) Darjeeling B. I. T. A. by the Chief Advisory Officer, West Bengal, and Advisory Officer, Darjeeling & Terai.

(iv) I. T.P. A. by Dr. N. B. Chanda.

(v) T. A. I. North Bengal Branch by Advisory Officer, Darjeeling & Terai.

The Chief Advisory Officer,West Bengal, attended the UPASI Scientific Conference and their annual general meeting during his visit to South India in September.

Area Scientific Committees

The three Area Scientific Committees in West Bengal held a total of 8 meetings, the Dooars and Terai Committees met 3 times each and the Darjeeling Committee twice. The Chief Advisory Officer attended all these meetings.

Meetings when possible were arranged to coincide with visits of Tocklai officers to Bengal. There was always a free exchange of ideas and all meetings provide extremely helpful and improved the liaison between the planter and scientific staff.

It was disappointing that only the two delegates from the Dooars Committee attended the Joint meeting of all Area Scientific Committees which was held in upper Assam in early March. The three day meeting was very well organised and all those attending were overwhelmed with the excellent hospitality and were impressed with the estates seen.

MISCELLANEOUS

Soil Testing

A total of 3,172 soil samples were analysed during the year.

Visitors

As usual a large number of visitors paid visits to the stations at both Nagrakata and Darjeeling. Mr. R. L. Hards, Chairman of the London Scientific Committee and Mrs. Hards paid a visit to Nagrakata during their tour of N. E. India. Mr. Hards also visited the Clonal Proving Station in Darjeeling.

Manufacture

The Association rented the miniature factory at Meenglass Tea Estate for the manufacture of experimental samples. Manufacture was started in August and a total of 1,500 samples were manufactured and samples were sent to Tocklai, Calcutta and London for testing. This is not a satisfactory arrangement and the sooner the miniature factory is built at Nagrakata the better.

Building and Land

The building of the new office block at Nagrakata was completed and the office was moved into the new premises in October.

A small bamboo bari was planted and about 3 hectares of land was ploughed in preparation for planting trials.

Meteorological Stations

Two fully equipped meteorological stations are maintained in West Bengal, one at Nagrakata H.Q. and the other at Nagri Farm T.E. in Darjeeling. Regular readings were recorded throughout the year.

Summary of Results

ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries as on the 1st of April, 1971, of some of the experiments conducted by the Department on member estates are given below:

Irrigation Cum-Pruning

North Bank, Assam

In experiment No. AN.74 on Assam kind of tea growing on loamy soil on irrigation-cum-pruning conducted during 1969, the effect of irrigation on early or total crop was not beneficial. Irrespective of irrigation, December pruning in prune - unprune-unprune cycle gave significantly the highest total yield followed by December pruning in prune - deep skiff-medium skiff cycle. July pruning in both the cycles, whether irrigated or not, gave significantly more early season crop while December pruning gave significantly more main season crop. However, December pruning produced significantly more total crop than July pruning in both cycles, irrespective of irrigation.

South Bank, Assam

In the experiment on irrigation-cum-pruning (AS. 68—Assam kind of tea on heavy soil) conducted in 1969, irrigation failed to increase crop. This may be attributed to good distribution of rainfall during 1968/69 cold weather. Unpruned tea gave the highest crop and was significantly better than December or July pruning. July pruning reduced the total crop in the year of prune but it gave more early season crop.

In another irrigation-cum-pruning experiment (AS. 73—Assam kind of tea growing on silty clay loam), there was no significant difference in 1969 in total yield between July and December pruning under irrigated conditions. Unpruned and irrigated tea gave significantly higher crop over July or December pruning. Without irrigation, unpruned and December pruning gave significantly more crop than July pruning. Irrigation produced significantly higher early and whole season crop over no irrigation.

Dooars

In experiment D.35 (Assam kind of tea, fine sandy loam), there was an 8% increase in early crop in 1970 due to irrigation, which was not significant. Irrigation made no difference to whole season crop. Under irrigated conditions, July pruning gave significantly more whole season crop than December pruning, but there was no significant difference under unirrigated conditions. Irrespective of irrigation, July pruning produced significantly more early season crop as compared to December pruning. Unpruned tea gave the highest crop.

Generally, irrigation failed to increase early or whole season crop in mature tea. This may be attributed to well distributed rainfall in the cold weather. July pruning reduces the total crop significantly in the year of prune but it gives more early season crop as compared to December pruning. Unpruned tea gave the highest crop.

Nitrogenous Fertilizers

High Frequency Application of Sulphate of Ammonia : Several experiments were in progress to study and compare the effects of single and high frequency applications of different levels of nitrogen on yield. The levels of nitrogen varied from 100 kg to 250 kg per hectare, applied in a single dose, or in 4 to 8 equal monthly doses. Results of some of these experiments are described below.

South Bank, Assam

In experiment AS.62 (Doolia jat growing on loamy soil), where the tea was top pruned, higher doses above 112 kg N/ha did not produce significantly more crop in 1970 and there was no benefit from divided doses. Treatments also failed to show any effect on crop distribution.

North Bank, Assam

In experiment AN.59 (Doolia and Khowang jats, red bank soil), the results in 1970 were similar to those of experiment AS.62. The tea was deep skiffed. The economics of manuring is shown in Table 1.

Table 1. Yield of made tea in kg/ ha and economics of manuring for the season, 1970

Treatments	Yield	Cost of fertilizer in Rupees/ha	Cost of application at Rs. 12.50/ha	Total cost in Rupees/ha	Net financial return in Rupees per hectare on the basis of marginal return of Re. 0.50, Re. 1.00 and Rs. 2.00 per kg of made tea		
					Re.0.50	Re. 1.00	Rs. 2.00
T_1 — N_{112} kg/ha in 1 application	2656	293.44	12.50	305.94	1175.03	2350.06	5006.06
T_2 — N_{157} kg/ha in 1 ,,	2938	411.34	12.50	423.84	1257.08	2514.16	5452.16
T_3 — N_{202} kg/ha in 1 ,,	2807	529.24	12.50	541.74	1132.63	2265.26	5072.26
T_4 — N_{247} kg/ha in 1 ,,	2662	647.14	12.50	659.64	1001.18	2002.36	4664.36
T_5 — N_{112} kg/ha (N 28×4)	2852	293.44	50.00	343.44	1254.28	2508.56	5360.56
T_6 — N_{157} kg/ha (N31.4×5)	2775	411.34	62.50	473.84	1150.58	2301.16	5076.16
T_7 — N_{202} kg/ha (N33.7 ×6)	2754	529.24	75.00	604.24	1074.88	2149.76	4903.76
T_8 — N_{247} kg/ha (N 30.9×8)	3026	647.14	100.00	747.14	1139.43	2278.86	5304.86
L. S. D. (P = .05)	N. S.						
C. V. % ...	8.2						

Dooars

In experiment D.33 (Betjan jat, sandy loam), there was no significant difference in yield in 1970 between 110 kg N/ha and 220 kg N/ha applied in single or divided doses.

Cachar

In experiment C.29 (Chumoijan jat growing on loamy soil), there was no significant increase in crop in 1970 with higher doses of nitrogen above 100 kg N/ha applied in single or divided doses. It was found that the net financial return on the basis of Re. 0.50, Re. 1.00 and Rs. 2.00 per kg of made tea of four divided applications of 100 kg N/ha was more than 100 kg N/ha applied in a single dose. In experiment C. 30 (Kalline jat growing on loamy soil), no benefit was observed in 1970 from more than 100 kg N/ha or from divided doses.

There was no gain from application of sulphate of ammonia at doses higher than 110-112 kg N/ha. It is, however, intended to apply high dose of potash next year to see whether there is any response to high dose of nitrogen in presence of potash. Besides, no benefit could be derived from divided doses.

NPK Manuring

South Bank, Assam

In experiment AS.34 (Doom Dooma and Khorijan jat, sandy loam), phosphate (P_2O_5) was applied at two levels i.e. at 11.25 and 22.5 kg/ha and potash (K_2O) was applied at 22.5 kg/ha in combination with 110 kg N/ha. In 1970, application of phosphate and potash did not significantly increase crop over nitrogen alone.

Experiment AS.44 (replanted in 1955 with Betjan jat, sandy loam soil) was started in 1964 to study the effect of different doses of phosphate and potash with a constant dose of nitrogen (112 kg/ha). In 1970, the levels of phosphate and potash were raised to 112 kg/ha each and phosphate was applied in the form of ammophos. The residual effect of the high dose of potash (224 kg K_2O per ha), which was applied in the first two years of the experiment, gave significantly more crop over N_{112} P_0K_0, N_{112} P_{112} K_0 and N_{112} P_{112} K_{112}. There was no significant difference between N_{112} P_0 K_0 and N_{112} P_{112} K_0 or N_{112} P_{112} K_0 and N_{112} P_{112} K_{112}.

In experiment AS.51 (Betjan, loamy soil) phosphate was applied at 25 kg/ha and potash was applied at two levels i.e. 50 kg and 100 kg/ha in combination with 100 kg N/ha. In 1970, application of phosphate did not significantly increase crop over no phosphate. However, the main effect of potash was significant. K_{50} and K_{100} gave significantly higher crop than K_0 but there was no significant difference in yield between K_{50} and K_{100}.

Cachar, Assam

This experiment No. C. 28 (planted in 1964 with Chandkhira jat growing on a bheel soil) was started in 1966 to study the effect of different levels and combination of NPK on young tea on bheel soil. There were two levels of nitrogen, phosphate and potash at 0 and 90 kg/ha. The main effect of potash was highly significant in 1970. The effects of nitrogen and phosphate and other treatment combinations were not significant.

Another experiment C.26 (Unknown jat, about 60 years old, bheel soil) was started in 1965 to find out the effect of nitrogen alone and a mixture of nitrogen, phosphate and potash on yield of mature tea on bheel soil. Nitrogen was appiled at 100 kg/ha and phosphate and potash were applied at two levels of 25 kg and 50 kg/ha. In 1970, as in 1969, neither nitrogen nor combinations of nitrogen, phosphate and potash produced significantly better yield over no manure.

Darjeeling

An experiment Dj.23 (China jat, coarse sandy loam), was started in 1965 to compare the effects of different combinations of nitrogen, phosphate and potash on the yield of tea. Nitrogen was applied at 65 kg/ha and phosphate and potash were applied at two levels of 22 and 45 kg/ha. In 1969, all treatments receiving fertilizers gave significantly more crop over no fertilizer. The main effect of nitrogen was highly significant but response to different levels of phosphate and potash was not significant.

Another experiment, Dj.22 (China hybrid, coarse sandy loam) was started in 1966 to compare the effects of different combinations of NPK on the yield and crop distribution of mature tea at middle elevation, and subsequently to find out the most optimum combination of P and K. The dose of nitrogen was kept constant at 65 kg/ha and P and K were applied at three levels of 0, 22 and 45 kg/ha. In 1969, N_{65} P_{45} K_{22} produced the highest yield which was significantly better than N_{65} P_0 K_{22}. Similar results were obtained in 1968. The effect of the different levels of phosphate and potash was not significant.

Application of phosphate at low levels i.e. 11.25 and 22.50 kg P_2O_5/ha did not significantly increase crop over no phosphate. However, the residual beneficial effect of application of high dose of potash (K_2O) at 224 kg/ha was observed even four years after application of the manures. Significant response to potash was obtained

in South Bank and on bheel soil in Cachar. In Darjeeling, the response to phosphate and potash was not significant in one experiment but in another experiment a combination of P_{15} K_{22} produced significantly higher crop than P_0 K_{22} in presence of a constant dose of 65 kg N/ha.

Effect of Gramoxone on the Uptake of Phosphate and Potash in Tea

An experiment, AS.92 (Assam kind of tea growing on sandy loam) was started in 1969, to study the effects of phosphate and potash on growth and yield of tea where weeds have been controlled by Gramoxone or by manual cultivation. Application of phosphate and potash at two levels i.e. 0 and 50 kg/ha did not improve yield in Gramoxoned areas in comparison to non-Gramoxoned areas in both 1969 and 1970. The main effect of phosphate was not significant in 1969 and 1970 whereas the main effect of potash was significant in 1970 only.

Effect of Spring and Autumn Application of Phosphate and Potash on Yield of Tea Where Gramoxone is Used for Weed Control

An experiment, AS.95A (Betjan jat growing on sandy loam) was started in 1969, to study the effect of spring and autumn application of phosphate and potash, on growth and yield of tea, where weeds are controlled chemically. The tea was manured with ammonium sulphate at 100 kg N/ha in the spring. In 1970, there was no significant difference in yield between the treatments.

Sulphate of Ammonia Vs. Calcium Ammonium Nitrate

In experiment AS.63 (Dhoedam jat, loamy soil), sulphate of ammonia, calcium ammonium nitrate and potash at 100 kg/ha were applied to mature tea in 1970 to see whether these were more beneficial than sulphate of ammonia alone in highly acid soils. There was no significant difference in yield between application of calcium ammonium nitrate and sulphate of ammonia, with or without potash. However, potash in combination with sulphate of ammonia gave significantly higher crop over sulphate of ammonia alone. Addition of potash to calcium ammonium nitrate did not produce significantly higher yield.

Liming

South Bank

In experiment AS.78 (Betjan jat on loamy soil), both one and two tonnes of slaked lime per hectare failed to produce any significant effect on the yield of tea in 1970 in presence of either 100 kg N/ha or 200 kg N/ha.

Soil analysis of experimental plots indicated that there was no appreciable change in soil acidity since 1969 inspite of lime dressings at 1 to 2 tonnes per hectare.

In experiment AS.77 (Betjan jat, sandy loam soil), liming at 1 or 2 tonnes per hectare reduced the crop significantly in 1970 in presence of 100 kg N/ha. With 200 kg N/ha significant reduction of crop occurred only when lime was applied at 2 tonnes per hectare. Soil analysis of experimental plots showed that the overall pH status has not altered at all since 1969. There was no significant difference in yield between the two levels of nitrogen.

North Bank

In experiment AN.80 (Tingamira jat, sandy loam soil), liming did not produce any significant effect on the yield of tea in presence of either 100 kg N/ha or 200 kg N/ha. No significant difference in yield was observed between the two levels of nitrogen.

Application of lime at 1 or 2 tonnes per hectare in highly acid soils did not generally affect the yield of tea significantly in presence of either 100 kg N/ha or 200 kg N/ha. However, a significant reduction in crop due to liming @ 1 or 2 tonnes/ha a year for three years, was observed in one experiment.

Soil Rehabilitation

North Bank, Assam

In experiment AN.46 (Clayey loam soil), where tea was replanted in 1966, previous sub-soiling and deep ploughing gave more crop in 1970 over no sub-soiling and no deep ploughing but the difference was not significant. Green cropping for two years produced significantly increased yield over no green crop or green crop for one year only.

Dooars

In one experiment D.28 (loamy sand soil), leaving fallow under *Mimosa invisa* for two years after subsoiling and deep ploughing produced the best result in 1970. Sub-soiling and deep ploughing gave significantly higher yield than no sub-soiling and no deep ploughing.

Deep ploughing and sub-soiling gave higher crop over no deep ploughing and no sub-soiling. Green cropping for two years produced the best result. It must, however, be noted that in one experiment where the soil was sandy, no benefit was accrued from these.

Soil Climatological Survey

A few experiments were started in 1962 to study the growth of different kinds of tea under widely varying soil and climatic conditions and also their response to different levels of nitrogen.

Five clones i.e. TV. 1, TV. 2, TV. 3, TV. 18 and 3/22 were used combined with nitrogen levels at N_0 N_{55} N_{110} and N_{165} kg/ha 100 kg of potash (K_2O) per hectare was applied in 1970 along with the normal levels of nitrogen in all the plots.

Results of one experiment in 1970 are given here.

Dooars

In experiment D. 24 (heavy soil), TV. 18 continued to give the highest yield. The main effect of nitrogen and clone were significant as shown in Tables 2 and 3. The interaction between clones and nitrogen levels were not significant.

Table 2. Main effects of nitrogen: Yield of made tea in kg/ha

Nitrogen doses	Yield
N0	1391
N55	1788
N110	1894
N165	1930
L. S. D. (P = .05)	211
(P = .01)	319
C. V. %	13.5

Table 3. Main effects of clones : Yield of made tea in kg/ha

Clone	Yield
TV.18	2364
TV.1	1801
3/22	1628
TV.2	1558
TV.3	1403
L. S. D. (P = .05)	180
(P = .01)	242
(P = .001)	320
C. V. %	12.3

There was a gradual increase in crop in clones TV1, TV2 and TV18 with the increasing dose of nitrogen. In TV3 the yield increased upto 110 kg N/ha and thereafter it showed a declining trend. In clone 3/22, the highest yield was obtained at N_{165} although difference between N_{55} and N_{110} was not significant.

Effect of Complete Defoliation on Yield North Bank

In experiment AN.58 (Bordubi jat growing on Red Bank soil), the effect of complete defoliation was compared with hand clean out of banjhis in annually or biennially pruned (PR/DS) tea. In 1970, complete defoliation reduced the yield significantly in both annually or biennially pruned tea.

Weedicide Trials

An experiment was laid out to find out the efficacy of a few new weedicides on the control of weeds. The chemicals used at different doses were Afalon, Nata, Brominal M, Amchem 64-263A, Amchem 66-132, Dinotaf, Gramoxone, Afalon + Gramoxone and Afalon + Nata. The results of the experiment were not conclusive and the promising chemicals viz. Afalon, Dinotaf, Afalon + Gramoxone will be tried again in the next year.

Agriculture Department

General

At the start of this report it is appropriate to record the sudden death of Shri H. D. Hazarika Manager, Borbhetta on the 30th December. Shri Hazarika served the Association for thirty years.

Shri A. K. Dutta M.Sc. (Agri.) joined this Department at Borbhetta as Scientific Assistant on 12th October, 1970.

RESEARCH AND EXPERIMENT

Rehabilitation of Land

The experiment on rehabilitation of uprooted tea areas (B 6.3) started in 1962, showed definite increase in yield as a result of green cropping. No significant yield difference was observed between one year green cropping and two year green cropping treatments. Subsoiling to a depth of 40 cm and deep ploughing before green cropping did not show any beneficial effect. The results are presented in Table 1.

Table 1. Yield of made tea in kg/ha

Treatment	1969 D.S. 63cm	1970 L.P. 55cm
No Green Cropping	492	494
One Year Green Cropping	644	652
Two Year Green Cropping	640	678
C. D. (P = 0.05)	118	102
C. V. %	18.7	15.8

L. P. stands for light prune, D. S. for deep skiff and M. S. for medium skiff

From the results of this experiment it appears that subsoiling may not result in increased crop under all conditions. The soil of the experimental area is a sandy loam and did not have a hard pan.

Planting and Spacing

The results of experiment B 104 reported in Annual Report 1969-70 followed the earlier trend.

A new experiment (B 8/1) with different clones, spacings and levels of nitrogen was planted out with clonal tea in 1966 and the results are given in Table 2.

Table 2. Yield of made tea in kg/ha

Treatment		Plants per ha	Years 1969 (L. P. 45 cm)	Years 1970 (D. S. 65 cm)
Spacing	120 cm × 22.5 cm	37040	818	1693
	120 cm × 30 cm	27780	511	1184
	120 cm × 45 cm	18520	563	1240
	120 cm × 90 cm	9260	358	786
C. D. (P = 0.05)			120	384
Clone	106/1		598	1414
	19/29/13		527	1037
C. D. (P = 0.05)			N. S.	272
Nitrogen	100 kg/ha		532	1120
	200 kg/ha		594	1331
C. D. (P = 0.05)			N. S.	N. S.
C. V. %			19.8	29.2

It can be seen that spacings and clones have affected yield significantly. Yields have increased with increasing plant population except in the 120 cm × 30 cm spacing treatment. This is probably due to the poor growth of plants in most of the plots under this treatment.

The Spacing × Clone interaction was significant and the results suggest that Clone 106/1 has responded more to closer spacings. The results are peculiar and normally one would have expected Clone 19/29/13 to respond more to closer spacings because of its relatively erect habit. The lower response of Clone 19/29/13 seems to be due to its poor coverage of the interrow spacings.

Another experiment on jat tea (B 8/2) started at the same time as Experiment B 8/1 has given some interesting results. The results are recorded in Table 3.

Table 3. Yield of made tea in kg/ha

Treatment	Plant - Population per ha	1970 (D.S. 65 cm)
120 cm × 120 cm	6944	646
120 cm × 90 cm	9260	714
120 cm × 90 cm (doubleton)	18520*	859
120 cm × 75 cm	11111	755
120 cm × 60 cm	13888	885
120 cm × 75 cm × 75 cm	13675	1047
C. D. (P = 0.05)	—	162
C. V. %	—	13.2

* Two plants planted in one hole mainly with the objective of developing a better frame and quicker ground coverage. Also, there would be no need to infill if one plant died.

From the results it can be seen that except for the doubleton planting there is a progressive increase in yield with increasing plant population. It was also observed that 120 cm × 75 cm × 75 cm spacing was significantly better than 120 cm × 60 cm spacing although the latter spacing had slightly higher number of plants per hectare. This result suggests that both bush population and bush arrangement are important factors in determining yield.

Pruning of Young Tea

In 1968 August an area was planted with Clone 106/1 in single hedge of 120 cm × 60 cm and staggered double hedge of 120 cm × 90 cm × 60 cm. The tea was decentred in October, 1968 at 15 cm to 23 cm from the ground. It was kept tipped at 55 cm till a full table was formed. Then the table was raised by 5 cm. In this way the table was raised twice in 1969 and twice in 1970. At the end of 1970 the table was at around 75 cm. No pruning/centering was done besides the one done two months after planting. The yields obtained in 1969 and 1970 seasons are recorded in Table 4.

Table 4. Yield of made tea in kg/ha

Spacing	Made tea in kg/ha	
	1969*	1970
Staggered double hedge 120 cm × 90 cm × 60 cm	496	1303
Single hedge 120 cm × 60 cm	571	1605

* 1969 yields recorded from July to November only.

Manuring

A number of experiments on different aspects of manuring have been conducted and are being conducted at Borbhetta. The results of

most of the experiments have been reported in Annual Report for 1969-70 and the trend of the results being the same many of the experiments will not be reported here.

Nitrogen Manuring

An experiment (B 110.2) was started in 1970 on well shaded 12 year old vigorous Khorijan tea to find out if reduction in the rate of nitrogen manuring affected crop adversely. The standard dose of nitrogen was 90 kg/ha and reductions in the standard dose to the extent of 10, 20, 30 and 40 per cents were made. The results are recorded in Table 5.

Table 5. Yield of made tea in kg/ha

Nitrogen dose kg/ha	Made tea in kg/ha D. S.
90	2002
81	1970
72	1948
63	1959
54	1938
C. D. (P = 0.05)	N. S.
C. V. %	4.1

1970 was the first year and under the conditions of this experiment no reduction in crop was observed even with a 40 per cent cut in the standard nitrogen dose. The experiment is being continued and yield records upto June 1971 have shown reduction in crop in proportion to the per cent cut in the nitrogen dose. It is considered that in many cases loss in crop may occur even in the first year.

Phosphate Manuring

An experiment (B 43 C.2) was started in 1970 to compare the efficiency of different sources of phosphate in the presence of 100 kg N and 40 kg potash per hectare. The treatments consisted of no phosphate, phosphate as superphosphate, ammonium phosphate, nitrophosphate and rock phosphate. The treatment effects did not differ significantly. The experiment is being continued.

In an experiment (B 105) where phosphate has been applied as superphosphate from 1960 at 0, 45, 90 and 180 kg per hectare significant decrease in yield was recorded in 1970 at the 180 kg/ha dose. There was a trend of decrease in crop at the lower doses also.

Potash Manuring

The results in respect of potash manuring from experiments B 5.1 and B 105 are presented in Tables 6 & 7.

Expt. B 5.1

Table 6. Yield of made tea in kg/ha without shade

(Seedling tea planted 1962)

Treatment	1968 D. S.	1969 L. P	1970 D. S.
No Potash	948	906	840
22.5 kg Potash/ha	1078	1024	980
C. D. (P = 0.05)	48	54	74
C. V. %	9.4	11.2	16.1

Expt. B 105

Table 7. Yield of made tea in kg/ha
(Clonal tea planted 1958)

Treatment	1967 L. P.	1968 D. S.	1969 M. S.	1970 L. P.
No Potash	926	1212	1404	1279
45 kg K_2O/ha	986	1350	1597	1530
90 kg K_2O/ha	1106	1452	1731	1596
180 kg K_2O/ha	1240	1618	1912	1625
C. D. (P = 0.05)	114	144	164	109
C. V. %	15.0	14.3	13.9	10.2

It is interesting to see that the response to potash was linear upto 180 kg per hectare until 1969 but in 1970 there was no response beyond 45 kg/ha. This suggests that the fixing capacity of the soil/plant system has been satisfied and most of the applied potash is available for growth.

The 1970 results of experiment B 5.1, where 4 levels of nitrogen were tried in combination with two levels of phosphate and two levels of potash demonstrate the nitrogen × potash interaction very clearly as can be seen in Table 8.

Table 8. Yield of made tea in kg/ha

Nitrogen / Potassium	No N	45 kg N/ha	90 kg N/ha	135 kg N/ha
No K	746	1061	839	714
22.5 kg K_2O/ha	726	1098	1186	913

C. D. (P = 0.05) = 148

There was no response to potash at 0 and 45 kg/ha nitrogen application rates, but there was significant increase in crop as a result of potash application at 90 and 135 kg/ha nitrogen levels. It can also be seen that with no potash there was significant decrease in crop when the nitrogen dose was stepped up from 45 to 90 kg/ha. These results suggest the need for a proper balance between nitrogen and potash manuring.

Shade and Manuring

An experiment (B 32.2) was conducted to study the effect of artificial shade and natural shade from different species of trees on tea and also their interaction with two forms of nitrogen. The combined analysis of the results from 1959 to 1966 showed that the effects of shade and forms of manure were significant. *Albizzia maranguensis* and *Parkia javanica* gave significantly the lowest yield. The other shade species *viz.*, *Albizzia lebbek*, *Albizzia odoratissima*, *Parkia filicoidea* and *Emblica officinalis* along with artificial shade and no shade did not differ significantly among themselves. It was also observed that yields under oilcake were higher compared to sulphate of ammonia. It is probable that oilcake supplied some other limiting fertilizer elements.

Forms of Nitrogenous Fertilizers

Experiments with different nitrogenous fertilizers were continued. The results obtained so far indicate that urea, ammonium sulphate and ammonium sulphate nitrate are equally efficient. Results in respect of calcium ammonium nitrate were inconsistent.

One of the objections to the use of fertilizers other than sulphate of ammonia is their poor handling and storage property due to absorption of atmospheric moisture. The rate of moisture absorption is mainly dependent on the relative humidity of the atmosphere and the kind of fertilizer. The property of absorbing moisture is termed as hygroscopicity and is expressed as percentage on oven dry weight basis.

The hygroscopicity of urea, ammonium sulphate, ammonium nitrate, ammonium chloride, calcium ammonium nitrate, ammophos, superphosphate, muriate of potash and sulphate of potash was studied and the data have been graphically represented in Figure 1.

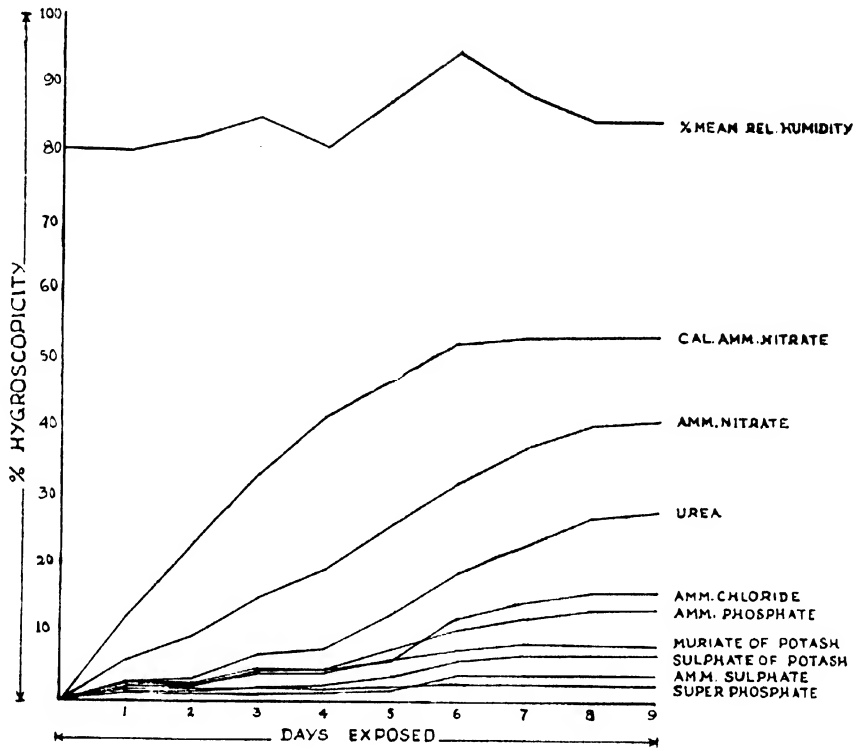


FIG. 1 RELATIVE HYGROSCOPICITY OF DIFFERENT FERTILISERS IN RELATION TO DURATION OF EXPOSURE

Among nitrogenous fertilizers calcium ammonium nitrate absorbed the maximum quantity of moisture and sulphate of ammonia the least. Single superphosphate was less hygroscopic compared to ammophos. Muriate of potash and sulphate of potash were more or less similar. The practical points that emerge from this trial can be summarised as follows :

(1) Ammonium sulphate and superphosphate have got the lowest hygroscopicity and there should be no handling problems.

(2) In general 8-10 per cent moisture is considered the maximum beyond which the physical condition of fertilizers deteriorates and handling becomes difficult.

(3) Bags of hygroscopic fertilizers should be used up and if for any reason loose fertilizers are to be stored, they should be stored in polythene lined bags securely tied.

Foliar Fertilization

Experiments were conducted to determine the safe concentration of N, P and K fertilizers alone and in mixtures for foliar application in nurseries and mature tea using hand sprayers and power sprayers. Details of the trials were reported in 'Two & A Bud' Vol. 17, No. 4. A generalised recommendation on the basis of these trials was developed and is presented in Table 9.

It should be clearly borne in mind that spraying was done carefully under personal supervision and where supervision could be lax it would be safer to use 75 per cent of the concentration given in Table 9.

Table 9. Safe fertilizer spray concentrations for nursery and mature tea

Fertilizer	Nursery plants 6 24 months	Mature tea under permanent shade		
	Holder Harridan	Micronette	Turblo Model B	Aspee Bolo
Urea	4%	20%	12%	8%
Ammophos	4%	12%	8%	4%
Muriate of Potash	4%	12%	8%	4%
N.P.K. mixture (2:1:2)	3%	12%	8%	4%

Cultivation and Weed Control

Five new weedicides namely Caldon, DSMA Powder, MSMA, Arsonate liquid and Timic (VCS-438) were tried at Borbhetta in 1970. Preliminary results are encouraging. Further trials with these weedicides are continuing.

Seasonal Dormancy in Tea

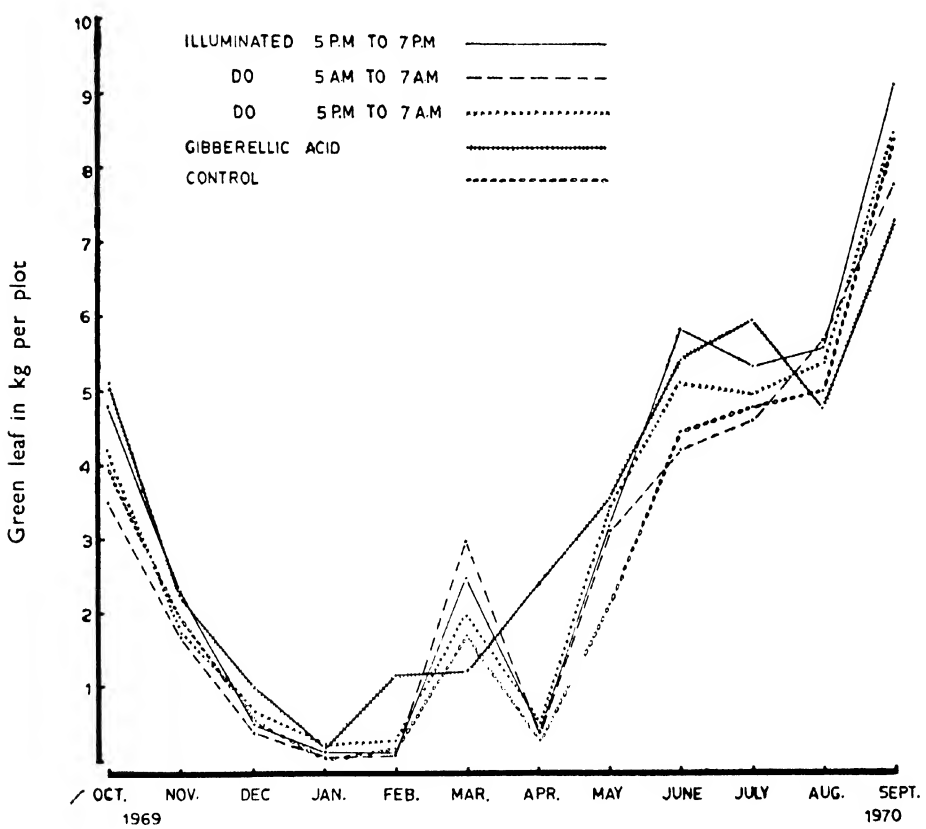
This experiment was initiated in September, 1969 to test the hypothesis that winter dormancy (December-February) of tea in North East India is caused by short day lengths. An unreplicated experiment was started in September 1969 at Borbhetta on Clone 19/29/13 planted in 1958 at 150 cm × 60 cm. One row of 44 bushes was used as one plot and the plots were plucked at weekly interval from September 1969 to August 1970. Some treatments were plucked till October '70. In the light treatments the long winter night was interrupted by one or two hours of weak artificial illumination given at different times, *viz.*, from 4 to 6 P.M., 6 to 8 P.M., 8 to 9 P.M., 9 to 10 P.M., 10 to 11 P.M., 11 to 12 P.M., 12 to 1 A.M., 1 to 2 A.M., 2 to 3 A.M., 3 to 4 A.M. and 4 to 6 A.M. In one treatment light was given from 4 P.M. to 6 A. M. Light was provided from ordinary 60 W bulbs which were hung 60 cm above the plucking surface at the rate of one bulb for six bushes. Shade was fabricated for the bulbs so that the light remained confined to the experimental rows only. Guard rows between experimental rows were kept unplucked to provide a barrier for diffuse light from one illuminated row to pass through to the adjacent experimental rows. In another treatment Gibberellic acid (GA) was sprayed on one row of 44 bushes starting from September 1969. From 6th November '69 to 13th January, 1970 GA solution at 10 p.p.m. was sprayed at two week intervals. Thereafter the concentration was increased to 100 p.p.m.

Three 100 p.p.m. sprays were given on 20th January, 3rd February and 17th February 1970. The quantity of fluid sprayed per bush was approximately 45 cc.

Increased yields were obtained in the GA treated plots and in the plots where light was given in continuation of the day length. It is proposed to discuss the results of only five treatments, *viz.*, GA, Control, 4 A.M. to 6 A.M., 4 P.M. to 6 P.M. and 4 P.M. to 6 A.M. illumination treatments. The monthly yield data of these five treatments are represented in Figure 2.

It can be seen that although treatments were started in September 1960 there was no appreciable treatment effect on crop till January, 1970. In February the GA treatment gave appreciably higher yield. There was a good flush but the shoots were very small resulting in low yields. The first flush in the other treatments including control was obtained in March. An alternation in the flushing-banjhi cycle as a result of GA spray can be seen clearly in the figure. All other treatments manifested pronounced banjhiness during April whereas GA treated bushes were flushing vigorously. It can, however, be seen that from May onwards the

FIG. 2 EFFECT OF GIBBERELLIC ACID AND ILLUMINATION ON CROP DISTRIBUTION



GA treated bushes did not behave differently from bushes in other treatments. This suggests that the stimulus provided by the GA spray in January/ February produced flushes upto May only. It was also found that although the cumulative total yield from September '69 to September '70 was high in case of GA treatment, the monthly yields started dropping from August onwards.

From the experiments that have been conducted so far at Borbhetta it is evident that GA can break the winter dormancy of tea but cannot ensure normal harvest during the winter. It can be seen that yields obtained in January were about 10 per cent of the October yields. It was also observed that the shoot size was very small and as such it seems safe to conclude that there is some other factor which is affecting the growth of shoots after their development. This aspect needs further investigation.

Effect on Quality

Tea was manufactured from March to September in 60 gm rollers. The results from 31st March to 9th September were subjected to statistical analysis and the treatment differences did not reach the level of significance. It would, thus, appear that GA application has not affected quality adversely.

BORBHETTA FIELD EXPERIMENTAL ESTATE REPORT

Labour—The average daily attendance of labourers during the current year, compared with the last four years, is as follows : -

Year		No. of labourers engaged
1966	...	247.57
1967	...	230.66
1968	...	220.00
1969	...	208.63
1970	...	188.30

Crop—The total yield of green leaf during the current year, compared with the last four years, is as follows :—

Year		Yield
1966	...	1,34,730 kg
1967	...	1,29,455 kg
1968	...	1,29,021 kg
1969	...	1,44,985 kg
1970	...	1,72,868 kg

Of the 1970 crop, 1,65,360 kg green leaf was sold to the Jorehaut Tea Co. Ltd., and the remainder was used for experimental purpose. General plucking was stopped on 30.11.70.

Vegetative Propagation—The following supplies were made to member estates/outstations from Borbhetta.

Supplies made	1969-70	1970-71
Pretreated/fresh cuttings	3,16,825	4,98,205
Scions	600	2,122
Clonal plants	900	300
Rooted cuttings of shade trees	18	12
Grass cuttings	Nil	1,100

SOIL CHEMISTRY

Cation Exchange Capacity of Clonal Tea Roots

It is possible that the pattern of root system of the various clones holds the key to the problem of fertilizer responses of the different genetic types. Important plant characteristics which are extensively studied for fertilizer responsiveness of both annual and perennial crops, are the cation exchange capacity (C. E. C.) of roots, and the pattern of root ramification.

Studies on the pattern of root ramification have received considerable attention at Tocklai during the past decade. No information is, however, available on the cation exchange capacity of tea roots. Therefore, studies have recently been initiated on some clonal tea to evaluate possible relationship between cation exchange capacity of roots and yield of tea, i. e. to define root cation exchange capacity values of clones which are more suitable for a given soil condition to ensure maximum efficiency in fertilizer use.

Two standard methods of C.E.C. determination were examined at Tocklai utilising whole root systems of ten different clones. The standard method was also modified at Tocklai to ensure better reproducibility and recovery of the C. E. C. values. The clones were of similar age, receiving same management treatments, but differing genetically and providing us a range from China and Indochina through hybrids to extreme Assam forms. The variations of root C. E. C. values observed between these ten different clones by both the methods have been found to be of the order of 20 mili-equivalents per 100 g fresh roots, which is considered to be large. The China and Indochina clones yielded appreciably higher C.E.C. values than the extreme Assam clones. The range of C. E. C. values extends between 33-35 mili-equivalent per 100 g roots for the extreme Assam clones (like clones 6/8 or 9BF) to 54-55 mili-equivalent per 100 g roots for the China and Indochina clones.

It has been observed that the white roots, which are believed to be the absorbing ones, contribute most to the C. E. C. of the whole root system. The data obtained with a China clone are given in Table 1.

Fresh, unmilled white roots have almost two and a half times C.E.C. value compared to the red roots. Further, it appears that with drying and milling, white roots undergo about 30 per cent decrease in C. E. C. though it remained unchanged for red roots under similar treatment.

The total uptake of cations (Calcium, Magnesium and Potassium) has also been measured by analysing the above-ground portions of the plants of the ten different clones. The results suggest that the total uptake of cations remains almost

Table 1. Cation exchange capacity values of fresh and dry white and red roots

Clone	Kind of root	Dried or fresh	Mili-equivalent cation exchange capacity per 100 g dry roots (mean of ten plants)
14/13/20	(i) White	Fresh, unmilled	89
	(ii) Red	,, ,,	37
14/13/20	(iii) White	Dried and milled	61
	(iv) Red	,, ,, ,,	35
	(v) 2/3rd white plus 1/3rd red	,, ,, ,,	41

constant for all the ten clones (the values ranging from 6.72 to 8.94 mili-equivalents), though the root C. E. C. values differ. However, further work is now in progress to find out the possible relationship between the C. E. C. values of roots, and the ratio of divalent (calcium) to monovalent (potassium) cations of the top growth.

The effect of age of plant on the root C. E. C. values was examined with two different clones, as a preliminary exercise. These data are given in Table 2.

Table 2. Influence of age of plant on the cation exchange capacity of fresh white roots

Clone	Age of tea	Mean mili-equivalent cation exchange capacity per 100 g dry roots.
TV_1	1 year	50.0
,,	2 years	54.0
,,	9 ,,	46.5
,,	13 ,,	37.5
TV_9	1 year	41.4
,,	2 years	48.4
,,	4 ,,	44.0

This study could not be carried out intensively, because of the non-availability of clonal plants of different ages. However, there is a distinct indication that after the second year, root C.E.C. values decrease with increasing age of the plants. The higher root C.E.C values during the first and the second years of planting, observed in case of both the clones, could be the influence of N.P.K. manuring in the field.

Cuttings from a wide range of clones suggested by the Senior Botanist have already been planted with a view to extend these observations.

Studies on the Behaviour of Soil Potash

1. Fractionation of soil potash : An attempt was made to estimate the various fractions of soil potash in two of our long-term N.P.K. experiments, one (B-105) sited at Borbhetta, and another (D-1) at Kalchini (Dooars). Both these experiments were started in 1958. Soils of Borbhetta Field Station and Kalchini Estate belong to sandy loalm and silty loam types, respectively. The results of the fractionation study are given in Table 3.

Table 3. Different forms of soil potash as influenced by long-term potash manuring at carying levels

Site	Fertilizer treatment, kg per hectare N.P.K.	p.p.m. total K_2O	p.p.m. potentially available (non-exchangeable) K_2O	p.p.m. readily available (exchangeable) K_2O	p.p.m. plant extractable K_2O (4 + 5)	Percentage of permanently fixed non-available K_2O
I	II	III	IV	V	VI	VII
Borbhetta	90.0.0.	2,700	200	82	282	90
,,	90.0.45.	2,900	253	119	372	86
,,	90.0.90.	3,600	275	139	414	90
,,	90.0.180.	4,900	315	190	505	90
,,	(Mean)	3,525	261	133	393	89
Kalchini	90.0.0.	2,900	538	70	608	79
,,	90.0.22.5	3,800	412	49	461	88
,,	90.0.45.	3,800	425	68	493	87
,,	90.0.90.	3,500	488	48	536	85
,,	(Mean)	3,500	466	59	525	85

The data suggest that though the total potash contents of both the locations are virtually the same, yet there are considerable differences between the sites in labile potash (see columns iv, v, and vi). By labile forms of potash is meant those forms which can contribute to the available pool over a time span. The percentages of non-available potash (i.e., permanently fixed form), which is of no consequence for plant nutrition, do not vary significantly between the two sites (see column vii). Compared to Borbhetta, Kalchini soils have double the quantities of potentially available potash (see column iv), and half as much as readily available potash (see column v), which means that Kalchini soils will take a much longer period of time to be exhausted of the potash reserves under continuous cropping compared to the Borbhetta soils. The results of the long-term trial at Borbhetta also suggest that, the readily available (exchangeable) form alone can serve as a good index for correlation studies with yield. The increases of both the readily available and the potentially available forms with increasing rates of potash manuring have been found to be proportionate. The labile forms of potash in the two extreme types of tea soils comprise only 10 to 15 per cent of the total potash. Therefore, regular manuring with potassic fertilizers for arresting depletion of soil potash reserves, appears to be necessary.

2. Evaluation of readily available (exchangeable) soil potash utilising various known extractants : Top (0-15 cm) soils from Borbhetta long-term N.P.K. experiment (B-105) were used for estimation of the readily available potash using nine different chemical extractants. The object is to find out whether the extractant used in our routine test of available potash is as good as any other extractants so far as correlation studies with yield is concerned.

It appears that both our routine method, and the method used by the National Agricultural Advisory Service of U.K. are comperable. Therefore, it is possible to switch over to the N.A.A.S., U.K., method in lieu of our routine method, specially when the auto-annlyser arrives. The N.A.A.S., U. K., method permits simultaneous determination of P and K in the same extractant with the use of an autoanalyser, which is not possible with our routine method.

There are indications that pairing potentially available (non-exchangeable) and readily available (exchangeable) potash estimates together in our soils, the best correlation between soil potash values and the yield can possibly be obtained ($Y = 1191.7490 + 0.9223X$, where y = yield in kg/ha, and X = soil potash value, $r^2 = 0.52$, $P = 0.001$).

3. Influence of long-term superphosphate manuring on the labile potash content of top soils : For this study, top (0-15 cm) soils of a longterm N.P.K. experiment (B-105) at Borbhetta were utilised. The results are given in Table 4.

Table 4. Changes in labile potash content of top soils due to long-term manuring (mean data expressed as p.p.m. K_2O).

Levels of potash dressing	Total labile potash contents of soils			
	$N_{90}P_0$	$N_{90}P_{45}$	$N_{90}P_{90}$	$N_{90}P_{180}$
K_0	308	283	220	233
K_{45}	351	373	263	317
K_{90}	561	401	378	351
K_{180}	580	408	443	414

The data indicate negative effect of long-term superphosphate manuring on the labile potash contents of soil, be it in water soluble, exchangeable or non-exchangeable forms (compare P_0, P_{45}, P_{90} and P_{180}). The individual fractions of labile potash namely, water soluble, exchangeable and non-exchangeable ones are, however, not given in the Table though estimated. It appears that continued use of superphosphate, even at a low dose of 45

kg/ha/year can result in 22 to 30 per cent decrease of the total content of labile potash. However, this observed decrease of labile potash does not seem to be proportionate with the increasing rates of phosphate application. The negative influence of superphosphate manuring on the soil potash was found to be more reflected on the water-soluble form of potash than either exchangeable or non-exchangeable forms. Since water-soluble forms are immediately available at a particular time, the observed negative influence of long-term superphosphate manuring should be viewed with concern.

The negative influence of long-term superphosphate manuring on the exchangeable potash content of top soils has also been observed in another N.P.K. trial at Borbhetta (B-5), results of which are given in Table 5.

Table 5. Changes in exchangeable potash content of top soils due to long-term manuring
(mean data expressed as p.p.m. K_2O)

Fertilizer treatment	N_0	N_{45}	N_{90}	N_{135}	Mean of N levels
P_0 K_0	39	47	40	32	40
$P_{22.5}$ K_0	30	28	28	28	29
P_0 $K_{22.5}$	95	63	60	52	68
$P_{22.5}$ $K_{22.5}$	48	39	46	54	47

Application of superphosphate at the rate of 22.5 kg per hectare P_2O_5 over a period of ten years resulted in about 30 per cent decrease in exchangeable potash content. The decrease has been found to be maximum with no nitrogen plots, and least with N_{135} plots. This is not unexpected, because of the greater leaching losses of soil potash with higher rates of application of sulphate of ammonia.

4. Potash fixation capacity of tea soils : It is important to study the potash fixation capacity of tea soils, since the fixation phenomenon regulates not only the supply of potash for plants, but also protects soil potash from leaching. A preliminary study was thus carried out under laboratory conditions, to find out the magnitude of fixation of applied potash.

Twenty top soils from different tea estates located in different regions of North East India were used for this study. With a view to saturate the soils with potash, a massive dose at the rate of 6 milli-equivalent K_2O per 100 g soil (roughly 4,000 kg/ha K_2O) was applied, and subsequently the fixation was measured. After addition of potash, the soil moistures were brought to field capacity and, thereafter, kept at room temperature for three days. Following the pre-treatments, each soil was extracted according to our routine procedure for determination of exchangeable (available) potash content. The amount of potash not extracted is termed as fixed.

The preliminary study suggests that the potash fixation capacity of these soils is rather low, varying between 5 to 27 per cent, and those showing relatively higher fixation capacity (12 to 27 per cent) are the heavier soils. Studies are now in progress to find out the possible relationship between clay content and the potash fixation capacity, utilising major soil types of the tea areas of North East India.

Potash fixation capacity of soil were also examined using soils of long-term N.P.K. trials, the object being to find out whether innate fixing capacity of soils undergo any change with long-term potash manuring. The results are given in Table 6.

The data suggest that, irrespective of the soil types, the potash fixation capacity of soils has not altered with long-term application of K_2O at rates 22.5, 45.0, 90.0 and 180.0 kg per hectare. Further the potash fixing capacity of both soils appears to be the same.

Table 6. Potash fixing capacity of soils from long-term N. P. K. trial fields

Estate/Trial field	Soils belonging to levels of potash in the long-term trial	Micro-gram potash added to to 100 g soil	Micro-gram potash released by extraction with neutral normal ammonium accetate	Micro-gram potash retained by the soil	Percentage fixation of applied potash
Borbhetta/B-105 (sandy loam)	K0	1,152 (roughly 2,000 kg/ha)	850	302	26
	K45		813	339	29
	K90		875	277	24
	K180		863	289	25
	(Mean)		850	302	26
Kalchini/D-1 (Silty loam)	K0	1,152 (roughly 2,000 kg/ha)	812	340	30
	K22.5		813	339	29
	K45.0		863	289	25
	K90.0		838	314	27
	(Mean)		832	320	28

This investigation was further extended to evaluate the influence of alternate wetting and drying on the fixation capacity of both estate and trial field soils. The results suggest that with the exception of Kalchini silty loam, potash fixation capacity of other soils remains virtually unaltered under the physical influence of alternate wetting land drying. The results obtained with Kalchini soils are shown in Table 7.

Table 7. Influence of alternate wetting and drying on the potash fixation capacity of Kalchini soils

Estate	Soil type	Trial reference	Microgram potash added to 100 g soil	Percentage potash fixed without wetting & drying	Percentage potash fixed after alternate wetting & drying
Kalchini	Silty loam	D/1	288 (500 kg/ha)	20	41
			576 (1,000 kg/ha)	23	37
			1,152 (2,000 kg/ha)	28	34

It seems that with this particular soil, potash fixation capacity increases with alternate wetting and drying, irrespective of the levels of added potash. However, the increase has been found to be maximum (two-fold) with lower level of added potash, and the order of increase due to alternate wetting and drying narrows down with the increasing rates of addition of potasssic fertilizers.

Field Trials On Mature Tea With Potash

A large number of simple trials have been laid out during 1970-71 at various estates located in different regions of North East India, with an aim to evaluate quickly the potash status of our soils and their need for potash fertilizers under commercial growing conditions. These simple K—fertilizer trials belong to two broad categories :

Category 1 : After initial assesssment of available soil potash, about one hundred simple field trials have been planned, where four levels of potash at 0, 50, 100 and 200 kg/ha or at 0, 40, 80 and 160 kg/ha are being tried out with a basal nitrogen level varying between 110 to 135 kg/ha.

Category 2 : Another one hundred and fifty simple field trials have been laid out in estates, where only two levels of potash (0 and a fixed level) are being tried out in combination with a basal level of nitrogen as applied in the estate. The fixed level of potash in these trials has been decided on the basis of prior information of available soil potash but varying between 40 to 100 kg/ha K_2O.

These simple trials have many replicates, but instead of laying out all the replicates in one particular site, these are dispersed over uniform soil types. Thus the average yield for any one of the potash levels pooled from different sites can be considered a soil type average within the frame work of the experiment. These simple trials need to be repeated for at least three seasons to arrive at practical recommendations.

The trials under category 1, i e., with four levels of potash, are useful for the purpose of finding out the optimum fertilizer rates. On the other hand, trials under category 2 are important for evaluation of potash fertility of our soils, since they measure responses of mature tea at a particular level of applied potash on different fields.

An additional important object of these simple field trials is to correlate crop response to potash fertilization in relation to the soil test values of available potash contents. For this purpose, available potash contents of the top soils of all the trial fields were measured before the start of the experiments. The changes in available potash contents as a result of the application of various rates of potash fertilizers will be determined during each cold weather for a period of three years. The correlations between yields, potash dressings, and the available potash contents of the soils once established for the different regions or for the different soil types will be useful for formulating fertilizer recommendations.

These trials will also offer us the scope to classify marginal values of available potash contents of our soils. At present we have arbitrarily accepted the following classification :

under	40	p.p.m.	: Low
	40-60	,,	: Low medium
	60-100	,,	: High medium
Above	100	,,	: High

which may not be valid in the light of the results from field trials.

Field Trials on Mature Tea With Nitrogen, Phosphate and Potash

About nine hundred soil samples from the top 15 cm layers of the nineteen trials under the Agriculture and Advisory Departments were sampled during 1970 prior to manuring, and were analysed for twelve different chemical and physical factors. The trials cover Jorhat (8 trials), Golaghat (1 trial), Moran (1 trial) and Margheritta (1 trial) areas in the South Bank; Bishnauth (1 trial) area in the North Bank; Longai (3 trials) Valley in Cachar; Mal (1 trial) and Kalchini (1 trial) areas in the Dooars; and Darjeeling (2 trials).

Texturally these soils cover silty clay loam, silty, loam, sandy loam and semi-peat types, and also nutrient-wise a wide range of fertility levels.

In collaboration with the Statistics Department, multiple regression analysis will be carried out in a computer.

These field trials were not originally designed to evaluate the effects of different soil and climatic factors on the response of tea to fertilizers. They also suffer from the drawback of insufficient fertilizer treatments. It is, however, hoped to establish a general multiple regression equation relating crop yield to the various soil factors and their interactions, with the ultimate aim to predict responses from fertilizers on the basis of soil test values.

SOIL PHYSICS

A vast majority of our land is subject to very high free water tables during the monsoon months. Therefore, the need for drainage in the tea areas has been emphasised during the past few years with an aim to increase the productivity potential. Local conditions of water table and soil permeability determine spacing between the drains, depth of the drains, and also the slopes of the bottom and sides of the drains. As a result, our present *interim* recommendations on the depth and spacing of drains may not hold good in different soil types. It is, therefore, essential that our knowledge on factors like water table and permeability be built up as quickly as is possible for designing efficient drainage system in different areas.

On the other hand, from the point of view of conservation, it is necessary to know the surface run-off, and the erosive loss of soils, especially for slopy lands.

Experiments have been planned during the year to obtain information on certain aspects of the drainage and conservation problems mentioned above.

Partitioning of Rain

When rain falls on the soil surface, a part of it is stored within the soil depending upon the infiltration capacity of the soil profile, and the state of moisture saturation of the entire profile. The rest is lost either as surface or ground run-off or simple evaporation. Surface run-off depends upon the intensity and the quantity of rainfall, slope, and the conditions of the soil surface.

Plate 1. Run-Off Plots Connected With Collector and Storage Drums

Run-off plots have been laid out (see plate 1) at Tocklai, with slopes of 1, 2.5, 3 and 6 per cent. These plots are 12 m × 3 m, and each slope has duplicate plots. After preparation of the plots, the soils were allowed to settle down to the desired density, i.e., equivalent to the density of a sandy loam top soils, before starting run-off mesurements. The plots have been surrounded on the three sides with masonry walls sunk deep into the sub-soil region (varying between 30 to 120 cm depending upon the gradients), to cut off water from the surrounding areas. At the end of each plot (i.e., on the remaining side), trapezoid shaped run-off collector has been installed, which in turn connects to ordinary oil-drums with a provision to catch about 550 litres of run-off water. The plan is to measure the surface run-off once every twenty-four hours during the rains. After measuring the quantity of run-off water in the individual drums, the drums will be emptied by pumping out the

water. A simultaneous measurement of the loss of soils is also planned, where an aliquot of the run-off water will be sampled at each observation to determine the suspended volume of soil.

A similar set of run-off plots have also been laid out on the Red Bank soils at Nagrakata with the co-operation of the West Bengal Advisory Department.

It is hoped that run-off measurements would be possible both at Tocklai, and at Nagrakata from August, 1971.

Available Soil Water Studies

The amount of available water in a soil depends on its physical characteristics particularly texture, and on the depth of the soil effectively used by plant roots. In a preliminary study, the relationship between the texture and the available soil water has been examined on certain typical tea soils.

The total amount of water available to the plants in any soil is the difference between the water contents at field capacity and at wilting point. The water contents at field capacity and at wilting point are determined by the use of a pressure plate and a pressure membrane apparatus set at 1/3rd and 15 atmosphere tensions, respectively. It should be mentioned in this connection that by field capcity moisture is ment that amount of water held in the soil against the downward pull of gravity. On the other extreme, at wilting point, the moisture can no longer be used by the plants at a sufficient rate to maintain turgor, and consequently the plant wilts.

The results of available water measurements in soils of different texture are given in Table 8.

Table 8. Available moisture content in the top layers (0-15 cm) of certain typical soils (mean of at least 24 replicates), data expressed as percentage on dry weight basis

Tea Estate	Texture class	Percentage moisture at 1/3rd atmosphere (field capacity)	Percentage moisture at 15 atmosphere (wilting point)	Percentage available soil moisture (F.C.W.P.)
Ghillidary	Silty clay loam	26.47	7.75	18.72
Dirok	,, ,, ,,	29.69	14.18	15.51
Sungma	,, ,, ,,	36.03	17.79	18.24
Khoomtaie	,, ,, ,,	25.44	10.07	15.37
Isabheel	Semi Peat	51.42	25.37	26.05
Hatikhira	,, ,,	49.33	21.40	27.93
Longai	,, ,,	45.50	21.52	23.98
Kalchini	Silty	30.70	5.09	25.61
Borbhetta	Sandy loam	15.08	4.85	10.23
Katonibari	,, ,,	14.77	5.08	9.69
Hunwal	,, ,,	14.97	5.02	9.95
Murmuria	,, ,,	13.45	4.46	8.99
Sycotta	,, ,,	15.80	6.40	9.40
Dekorai	,, ,,	13.66	5.22	8.44
Needam	Loamy	19.91	10.75	9.16

The available moisture contents of soils vary with texture, the order being semi peat > silty> silty clay loam> sandy loam > loam.

Determination of Soil Permeability

The importance of permeability measurement for determining the spacing and depth of drains has been emphasised earlier in this report. Brass

Plate 2 Permeameter Units Connected with Constant Head Tank

permeability cells (according to the method prescribed by the American Society of Soil Science) of size dimensions 5 cm height and 5 cm internal diameter have been made locally, which are snugly fitted into brass heads of size dimensions 10 cm height and 5 cm internal diameter. An assembly of twelve such permeameter units is connected with a constant head tank (see plate 2) for determination of hydraulic conductivity. The technique though simple failed to give us entire satisfaction from the point of view of reproducibility. Modifications are now being examined. Meanwhile a range of values obtained for typical tea soils from measurements already made are given in Table 9.

The data suggest that hydraulic conductivity is not only governed by the textural characters (sandy loam > silty> silty clay loam), but possibly more by the structure. Semi-peat soils have not only a high state of aggregation, but also comprise of more than fifty per cent coarser aggregates, i.e., those at or above 1 mm in size.

Agricultural Meteorology

Water Table

Measurements of ground water table throughout the year, have been carried out at Tocklai since 1966. A correlation study was made between ground water table and rainfall data available between 1966 to 1970, with an aim to find out the contribution of rainfall in charging the ground water table. The statistical analysis shows that the contribution of rainfall towards charging ground water table decreases, as it is expected, with the passage of time from March to September. Assuming a porosity of 25 to 30 per cent at 120 cm below the soil surface, the contribution of the effective rainfall (i. e., that fraction which charges the ground water level) appears to be about 20 per cent in September. However, this estimate needs confirmation on the basis of the porosity measurements of the impermeable sub-soil layers at depths between 90 to 120 cm.

To study the growth and nutrient uptake of the tea plants, in association with water tables at depths of 45, 90 and 135 cm from the soil surface, tanks made of G. I. sheet are being installed.The arrangement comprises of an inner tank of 1.5 m × 1.5 m × 1.5 m with wire-mesh at the bottom, placed within an outer tank of 1.8 m × 1.8 m × 1.8 m (see plate 3). The outer tank is provided with water outlets at desired distances from the surface

Table 9. Measurements of hydraulic conductivity in top layers (0–15 cm) of some typical soils (mean of at least six replicate measurements)

Tea Estate	Texture class	Hydraulic conductivity cm/Sec.	Tentative permeability class
Ghillidary	Silty Clay Loam	4.6×10^{-4}	moderately slow
Dirok	,, ,, ,,	4.6×10^{-4}	
Isabheel	Semi - Peat	173.3×10^{-4}	very rapid
Hatikhria	,, ,,	173.4×10^{-4}	
Longai	,, ,,	138.4×10^{-4}	
Kalchini	Silty	6.8×10^{-4}	moderately slow
Borbhetta	Sandy Loam	9.4×10^{-4}	moderate
Katonibari	,, ,,	9.3×10^{-4}	
Humwal	,, ,,	9.2×10^{-4}	

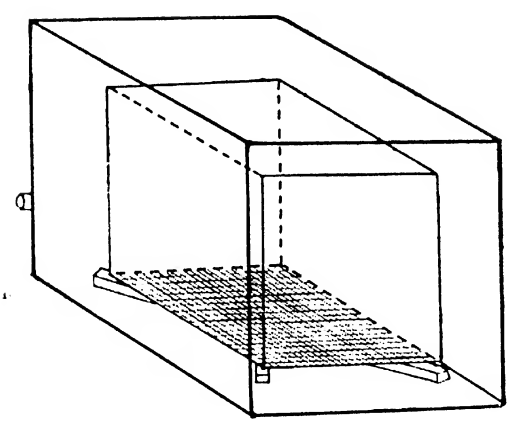


Plate 3. Diagram Showing an Unit of two Tanks for Studying Effects of Water Table on Growth of Tea

to allow maintenance of water tables in the inner tanks at depths of 45, 90 and 135 cm from the surface. The inner tanks will be filled with soils in the natural sequence occurring in the field, and these soils will be allowed to settle down until the autumn of 1971, before starting the experiment.

Summary of Meteorological Data

Meteorological conditions in ten-day units have been given for 1970 for all the four meteorological sites, and a summary of the observations for 1970 is given in the Appendix.

Research and advisory analysis

About 30,000 soil analyses have been made during the year. The break-up is as follows :

(i) **Research :** For Soil Department's project, as well as for the other departments, 12,000 estimations.

(ii) **Advisory :** For tea estates alone 18,000 estimations.

The demand for soil analyses by the estates was more than in the previous year. Besides analysis of soils from replanting, extension and nursery areas, estates often requested potash analysis for very large areas for ascertaining the potash requirement of their soils. Detailed soil analyses for problem areas have been undertaken at the request of the estates.

PLANT IMPROVEMENT

Release of Biclonal Seed Stocks

As reported in the Ann. Rep. for 1969-70, p. 40, the two biclonal seed stocks, Nos. 449 and 450, were released during the year for production of seed on a commercial scale. The characteristics of these two stocks had already been described in the last Annual Report. Two more biclonal stocks are awaiting release within a year or two.

Trial of Biclonal Seed

Samples of seed from one new biclonal seed stock (stock 458) were distributed for district trials. This stock is a cross between two high quality Assam clones and is expected to fill the need for a stock producing traditionally "Assam" kind of tea with higher yield.

Progenies of three more biclonal stocks will be planted during 1971 at Tocklai in long term trials. The experimental seed baris of eight biclonal combinations established at New Tocklai area (Ann. Rep. 1968, p. 50) and the polyclonal seed bari established in 1967, are expected to produce seed from 1972.

Six more biclonal combinations were selected for planting small seed baris to produce seed by natural pollination.

Cytological Investigation

Detailed Karyotype analysis carried out on a large number of clones from different varieties of tea failed to show any appreciable difference in their chromosome morphology.

The chromosomes are in general small and without much size difference in the complement. Due to their median or nearly-median primary constrictions, the tea chromosomes may be considered primitive. Minute differences in the chromosome complements such as structure and number of chromosomes with secondary constrictions, total chromatin length etc. were observed between individual clones. However, none of the differences could be correlated with any of the morphological characters of the clones.

Cytological investigations were carried out on a number of inter-specific hybrids between tea and *Wilson's Camellia* (*C. sinensis* var. *assamica* × *C. irrawadiensis*). The hybrids show extremely regular meiosis and high fertility, indicating close similarity in the chromosome complements of the two species. Morphological resemblance of the hybrids to cultivated tea further supports the earlier findings from morphological, anatomical and chemical studies at Tocklai that some inter-specific hybrids occur in cultivated tea populations.

The hybrids are showing extreme vigour in growth and yield and are under observation for use in future breeding schemes

Induction of Mutation

Earlier attempts at induction of mutation by irradiation of seeds with Gamma rays and treatment with chemical mutagens being abortive (Ann. Rep. 1968-69, p. 51; 1967-68, p. 53), pollen grains irradiated with X-rays at various dosage were used for pollinating a few selected clones in order to investigate the possibility of inducing mutations in tea by radiation treatments of the pollen. Some fruits have been formed by the irradiated pollen. If viable seedlings can be obtained from the seeds so formed, the method would be tried on a larger scale.

Release of Vegetative Clone

One more clone, TV 18, was released to the Industry during the year.

TV 18 is a yield clone, with excellent growth habit and very high yield potential. Leaf of this clone is of medium size, suitable particularly for C. T. C. manufacture. Quality is average with a touch of 'minty' flavour. The clone is hardy and likely to do well in drought prone areas.

Selection of Vegetative Clones

About 110 bushes form different commercial jats, biclonal and polyclonal progenies were screened during the year for the selection of elite vegetative clones. From yield records and manufacturing results, 43 bushes were selected for rooting and long term trials.

Another lot of 90 clones are under different stages of long term trial, out of which two more clones have been tentatively selected for release in the near future.

Stock-scion Compatibility

Reciprocal grafting of low, medium and high vigour clones has shown that for successful grafting, the stock should be more vigorous than the scion. Grafting of vigorous clones on root stocks of poor vigour results in little or no success.

A vigorous stock increases the vigour and leaf yielding capacity of a poor scion. Tasting results suggest very little, if any, effect of the stock on the cup quality of the scion.

Full details of these investigation are prepared for publication.

PLANT PHYSIOLOGY

Photosynthesis Studies

In continuation of the studies reported in 1968 and 1969, a series of experiments was carried out to observe the effects of increasing carbon dioxide concentration on the rate of photosynthesis of mature leaves at various light intensities. It is known that for many plant species, the normal concentration of carbon dioxide in the atomosphere (0.3% or 300 ppm) is limiting at certain light intensities.

Leaves were enclosed in plastic leaf chambers in controlled environment growth cabinets and air containing known concentrations of carbon dioxide was passed at 0.5 litre per minute into the chambers which were connected to an Infra Red Gas Analyser. Humidity, light and temperature were carefully controlled and the only known variable was carbon dioxide. Concentrations of 285, 350, 430 and 620 parts per million of CO_2 were used, the values having been guaranteed by the manufaurers. Three light intensities were used, the lowest corresponding approximately to the level found at the base of the canopy of unpruned tea (0.02g cal/cm²/min approximately), the next to the level found at the base of pruned tea (0.03g cal/cm²/min approximately) and the high light about that at the surface of a shaded bush under *Albizzia odoratissima* (0.16g cal / cm² / min approximately). Results are shown in Figure 1, where the uptake of carbon dioxide per gram dry weight of leaf is plotted against the carbon dioxide concentration of the assimilation chambers in parts per million.

FIG. 1

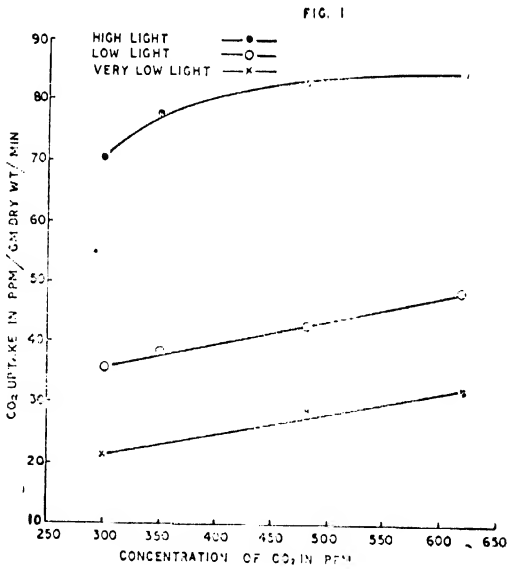


Fig 1. Rate of photosynthesis expressed as parts per million carbon dioxide taken up per gram dry weight of mature leaves per minute at carbon dioxide concentrations varying from 285 to 620 parts per million. Measurements were made at three different light intensities : very low (approx, 0.02 g cal cm^{-2} min^{-1}), low (approx. 0.03 g cal cm^{-2} min^{-1}) and high (approx 0.16 g cal cm^{-2} min^{-1})

At each light intensity there is an increase in the rate of photosynthesis with increase of carbon dioxide concentration, the percentage increase being greater with decreasing light intensity. If the range 300 ppm to 620 ppm is considered as normal to approximately twice normal concentration of carbon dioxide of the atmosphere, then the percentage increases are 20%, 33% and 45% as the light decreases.

In the field it would not be practicable under present conditions to supply CO_2 by chemical means, although air inside special houses for growing cuttings could be enriched with it. It is, however, known that heavy mulch releases considerable amounts of carbon dioxide and that due to the impedence to diffusion caused by the dense canopy of tea leaves near the ground, which reduces wind speed to almost zero, the lowest (i.e. most heavily shaded) leaves are in a position to utilise some of the extra CO_2. It is possible that some of the benefits derived from mulching are due to the effect of increasing photosynthesis in those heavily shaded lower leaves which are normally both light and CO_2 limited.

Drought and Waterlogging

In the Annual Report for 1969-70, pp. 41-42, rates of photosynthesis under extreme conditions of drought and waterlogging were presented. Information based on another exploratory trial is briefly reported here.

Eighteen month old potted clonal plants were divided into three groups. Group A was initially watered to field capacity and then unwatered for the duration of the experiment (Drought series). Group B was immersed to the base of the stem in water (Waterlogged series) and Group C was kept well watered (Control series). The experiment was carried out during January-February, 1971 and the following observations were made:

(a) Leaf turgor (the amount of water in the leaf compared to the amount at saturation)
(b) Transpiration rate
(c) Leaf temperature
(d) Soil moisture
(e) Soil structure
(f) Root growth

The most striking feature was that after more than six weeks under water, there was no visible symptom of waterlogging in plants of Group B and experienced observers could not differentiate between these plants and the controls. However, after washing out, the roots of the waterlogged plants were found to be rotted, scanty and almost half the weight of the controls.

Relative Turgor : This was determined in the usual manner by taking leaf discs of one cm diameter from similarly situated leaves of the three groups of plants, weighing them and then floating in distilled water for 24 hours. The fresh weight was again measured after carefully removing surface moisture and the discs were oven dried at 80°C and the dry weight determined.

The ratio $\frac{\text{Initial Fresh wt.} - \text{Dry wt.}}{\text{Fresh wt. after floating} - \text{Dry wt.}}$

is the Relative Turgor which is a measure of the moisture content of the leaf compared to its value at saturation and is expressed as a percentage. Samples were taken at intervals for four weeks and results are given in Fig 2.

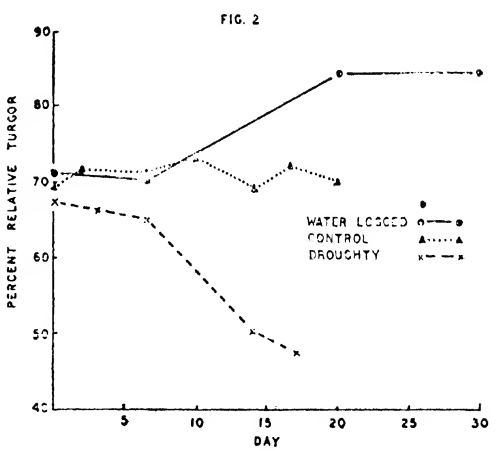


Fig 2. Relative turgor of mature leaves of control, water logged and droughty tea plants

It can be seen that the value of Relative Turgor (R. T.) for the controls was between 65-75%, the higher values associated with the period immediately after heavy watering. The droughted plants were also in this range until a week after watering ceased and then showed a rapid and regular fall in value to about 50% R. T. when permanent wilting occurred and the leaves dried up. The values for the waterlogged series started to rise after 8-10 days and maintained a high and constant value of 85% until the end of the experiment.

Transpiration Rates : Waterlogged and control plants were sealed in alkathene bags to prevent evaporation from the soil. They were weighed daily to 1.0 gram on a pan balance and replaced in the open. Total leaf area of each plant was determined at the end of 7 days and the results are given in milligram moisture loss per leaf per day, leaves being converted to a standard size for brevity in presenting results (Table 1).

Table 1. Transpiration loss from waterlogged and control plants

	mg moisture loss per leaf per day
Waterlogged plants	220.7
Control plants	354.8

In spite of the higher Relative Turgidity of the waterlogged plants, there was a marked reduction in the transpiration rate. This became even more apparent later in the experiment when some of the waterlogged plants were removed from the water and the soil sealed in polythene. After about 10 days in the open, symptoms of wilting were observed. The relative turgidity of the effected leaves was reduced to 55% (about the same value as the droughted plants) but the soil moisture had only dropped from 28% to 20% i. e. to about field capacity. In spite of ample soil moisture the plants were incapable of taking it up in sufficient quantities to maintain leaf turgor and a condition of physiological drought occurred. The permanent wilting of the control plants occurred at about 5% moisture compared to 20% of the waterlogged plants.

It is proposed to repeat this experiment during the summer months.

Mechanical Analysis of Waterlogged Soil: In view of the above findings the soil was analysed for aggregate structure and the results are given in Table 2.

There was also evidence of "slaking" in the waterlogged sample. This rapid deterioration in soil structure is obviously more severe than one would expect under normal field conditions and the decrease in size of the soil particles means that water will be more tightly 'bound' to the smaller particles and not as readily available to the plant roots. Besides, under the virtual anearobic conditions of the roots, it was suspected that some toxic substances may also have been produced. The rotted roots smelt strongly of hydrogen sulphide and this was confirmed by carefully washing the root system in distilled water, grinding and making it into a suspension which decolourised iodine solution. Hydrogen sulphide is known to be toxic to

Table 2. Values of aggregate analysis in percentage of aggregates

Aggregate size	5 mm	5-2 mm	2-1 mm	1-0.5 mm	0.5-0.25 mm	Total
Waterlogged sample	23.25	28.15	11.83	6.53	14.28	84.04
Control sample	42.22	30.04	5.28	3.65	8.12	89.31

most plant roots in extremely low concentrations and its presence would account for the death of the younger, more active roots.

Although this experiment was carried out under extreme conditions, there is reason to suppose that similar, if not as marked conditions, would obtain in waterlogged areas on heavy soils.

It is worth while considering whether the use of weedicides in badly waterlogged areas will be deleterious as root growth is an important factor in improving soil structure and hence aeration. Complete removal of all weeds will reduce the volume of organic matter in the top few inches of soil and the lack of cultivation may aggravate the situation. Once a suitable drainage system has been installed and found to be effective, the position is very different and weedicides may be used without concern.

Light and Withering

After its removal from a bush, the photosynthetic ability of a tea shoot is greatly reduced and under normal conditions of withering there is a marked loss of dry weight due to the high respiratory rate of young tissue. In an experiment to determine the respiratory rate of plucked shoots over a prolonged period, it was observed that when the laboratory lights were switched on there was a marked reduction in the respiration rate even 18 hours after the shoots were plucked. Further experiments were carried out to confirm this finding and results from a typical run are shown in Table 3.

Table 3. Respiration rate of withering tea shoots in artificial light and darkness

	CO_2 evolved parts per million/g dry wt. Average for 18 hours	Total loss in 18 hours mg/g dry wt.	% loss
Respiration rate in darkness	53	42.53	4.25
Respiration rate in artificial light	24	19.30	1.93

If withering was carried out in darkness for 18 hours the total loss of dry weight would be 4.2 mg per gram, whereas if the shoots had been illuminated with ordinary room lighting the loss would have been approximately half at 1.9 mg per gram. Similar results could also be expected in artificial systems of withering where the period of wither may be less but the temperature would be greater. The Senior Research Engineer carried out trials to observe the effect of lighting during withering on quality. No deleterious effects were observed and in many cases the illuminated samples were preferred by the Tocklai Taster. It should be noted that if the source of lighting generates a lot of heat, the wither will be very uneven and the resulting made teas will be poorer.

Judging from the uptake of water by leaf disks, the physiological activity of the leaf does not seem to be impaired even at higher degrees of wither than normally practised in the plains of N. E. India. Table 4 shows the amount of water taken up by leaf disks at different stages of wither.

Table 4. Amount of water taken up by withered leaf disks

Fresh wt. of disks (g)	Wt. after withering	Per cent wither	Wt. after floating in water (g)	(4) as % of (1)
1	2	3	4	5
1.231	1.029	83.6	1.346	101.7
0.682	0.542	79.5	0.746	109.4
0.706	0.509	72.0	0.719	101.7
0.902	0.648	71.9	0.917	101.7
0.740	0.416	56.2	0.707	95.5

Plucking Round

Observations reported in the Ann. Rep. for 1969-70, p. 46 were extended to three TV and one estate clones. The clones were pruned 1.5 cm above the previous pruning level in December 1969 and plucked on 3, 5, 7, 9 and 14 day rounds. Shoots bigger than 2 + bud were broken back above the third leaf, the broken back portions being weighed separately. Single banjhies were weighed in with

the 2 + bud fractions and the double banjhies with the broken back portions. Each treatment (plucking round) was repeated three times on single bushes and the harvest was divided into three seasons; early (from end April to end June), main (July to September) and back end (from October to end November).

Analysis of variance of the finer 2 + bud fractions and the gross weight of harvests (including the broken back portions) was done separately. The analysis of the finer fraction shows that clones differ at the 5 per cent level of probability, the plucking rounds and season at 0.01 per cent level and the first order interaction of clone × season, season × treatment, and the second order interaction of clone × season × treatment are all significant at 0.01 per cent level. The analysis of the gross weight of harvests also gives similar results.

These observations can be summarised as:

(1) Length of the plucking round influences crop, but not in the same way on all clones. In other words, adjustment of the plucking round will be necessary to obtain maximum crop from different clones.

(2) The yearly distribution of crop varies from clone to clone.

(3) Plucking rounds should be adjusted to the time of the year. A fixed plucking round all through the year will not give the maximum crop.

(4) The adjustment indicated in (3) must take into consideration also the clone, i. e. the adjustment will be different for different clones.

It will not be possible to present the full results in this short report; only the treatment totals are given in Table 5.

The proportion of banjhi shoots increased with the length of the plucking round as shown in Fig. 3. The highest proportion of banjhies was harvested in 14-day rounds and the lowest, in 3-day rounds. In all treatments, the banjhies showed a steep rise from early September but the difference between the plucking rounds further widened in the back end of the plucking season.

Effect of Removal of Banjhi Shoots on Yield

Removal of the banjhi shoots that are left on the bush frame after pruning is known to increase yield and this has become a standard practice in N. E. India. Presence of these banjhi shoots appears to retard the development of new shoots. Amongst the primaries which develop from dormant buds on the bush frame after pruning, some become banjhi before reaching the tipping level and new dwarf shoots appear on the bush frame. To test whether these newly developed dwarf shoots also exert a retarding influence on shoot growth, an exploratory trial was carried out during the year, in which dwarf shoots and primaries that went banjhi below the tipping level were removed from

Table 5. Grams fresh weight of shoots harvested per sq metre of bush surface in plucking rounds of different length

Length of plucking round	No. of times plucked	Clone 19/29/13		Clone 106/1		Clone 14/9		Eastate clone	
		Wt. of 2 + bud	Gross wt.	Wt. of 2 + bud	Gross wt.	Wt. of 2 + bud	Gross wt.	Wt. of 2 + bud	Gross wt.
3 days	74	2133	2135	1770	1770	1437	1603	1942	**1942**
5 ,,	45	2009	2097	1898	2034	1624	1811	1751	**1911**
7 ,,	32	2409	2736	2082	2460	1207	1468	1882	**2244**
9 ,,	25	2075	2567	1634	2304	1499	2287	1477	**1980**
14 ,,	16	1575	2482	1965	3800	1179	2399	1514	**2631**

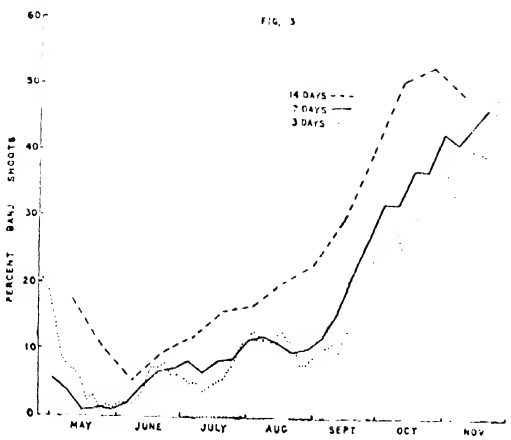


Fig 3. Number of banjhi shoots expressed as percentage of the total number of shoots plucked at 3, 7 and 14 day plucking rounds, from May to November

the bush at their point of origin just before tipping. Nineteen year old bushes of four clones differing widely in their growth habit were used for this trial, using two bushes of each clone for the treatment and two adjacent bushes as untreated controls. Yields from the treated and untreated bushes were recorded at each plucking round. Table 6 gives the green leaf yield per bush.

Table 6. Yield of green leaf per bush in grams

	Clone				Total
	19/48/16	19/30/6	19/2/16	19/13/13	
Untreated (Control)	1,317	1,468	1,769	1,556	6,110
Treated	1,826	1,618	1,903	1,655	7,002
% increase of treated over control	38.6	16.2	7.6	6.3	14.6

The increase caused by treatment varied between clones from 38.6 to 6.3 per cent, the average increase being 14.6 per cent.

These encouraging results promted us to plan a statistically designed, large-scale trial for 1971.

Formation of Flowers and Abscission of Leaves on Tea Seed Trees

These observations have been published in a paper by P. K. Barua in the Annals of Botany, Vol. 34, pages 721-735, 1970, a summary of which is given in Appendix C of this report.

It should, however, be noted that on a plucked bush the fall of leaves is not governed by the phasic activity of the apical bud, because shoot apices are removed in tipping. Observation shows that maintenance leaves can remain on a plucked bush for as long as 18 months.

Shoots Growth on Pruned and Skiffed Bushes

Clones and seed populations are reported to vary in their responses to lighter forms of skiff such as medium and light skiffs. To examine the causes of this differential response, 20-22 year old bushes of four clones were pruned, deep skiffed and medium skiffed in successive years, according to the standard Tocklai procedure. The four clones available for observation were of average vigour and their growing conditions in a replanted and unshaded site at Tocklai would compare favourably with many of the areas of replanted tea in the plains of N. E. India.

Counts were made of the number of primaries in the pruned year, number of stubs (cut branch heads) in the deep and medium skiffed years, number of shoots plucked per bush and the total weight of shoots harvested from the bushes in weekly rounds. These results are given in Table 7.

Table 7. Number of Primaries in the Pruned (P) year and stubs in the Deep Skiffed (DS) and Medium Skiffed (MS) years, relative shoot yield per primary and per stub and relative yield of green leaf per primary of the pruned year

Clone	Number of primaries per bush in the pruned year	Yield per bush in pruned year in grams	Number of stubs per primary			Shoot yield per primary and per stub in grams			Relative yield per primary of the pruned year in grams		
			P	DS	MS	P	DS	MS	P	DS	MS
1	2	3	4	5	6	7	8	9	10	11	12
16/12/15	157	1091	1.00	1.90	2.62	6.96	3.61	2.98	6.96	6.86	7.81
1/7/1	116	1526	1.00	1.86	2.52	13.11	8.16	5.44	13.11	15.18	13.71
16/10/8	293	1337	1.00	1.57	2.10	4.56	3.72	2.79	4.56	5.84	5.86
16/8/7	152	1341	1.00	1.87	2.45	8.82	5.41	3.43	8.82	10.12	8.40
Average	179	1326	1.00	1.80	2.42	8.36	5.22	3.66	8.36	9.50	8.94
				Per cent increase over pruned year						13.6	6.8

The number of primaries per bush in the pruned year varied widely between clones, without any relation to yield. The clone with the least number of primaries (1/7/1) yielded more than the one with the highest number (16/10/8), because of low productivity per primary of the latter clone (col. 7). Although the number of stubs per primary increased nearly two fold and two and a half fold respectively in the deep skiffed and medium skiffed years, productivity per stub decreased steeply. The products of these opposite trends, shown in cols. 10, 11 and 12, determine the yield of a clone in the pruned, deep skiffed and medium skiffed years. In the deep skiffed year, three out of the four clones showed significant increase in yield over the previous pruned year, while in the fourth clone (16/12/15) there was neither increase nor any significant decrease. In the medium skiffed year, only one out of the four clones showed significant increase in yield over the previous deep-skiffed year, two clones showed significant decrease and the fourth clone did not show any change.

Other observations show that shoot number of a clone increases in the order prune: deep skiff: medium skiff, while weight per shoot decreases in the same order. Branches subtending the pluckable shoots also become progressively thinner in the above order. It is also seen that strong primaries produce thicker first and subsequent orders of laterals than weak primaries.

Analysing the results of Table 7 in the light of these facts, it appears that deep skiffing will increase yield of all tea bushes in the plains of North East India, unless their growing conditions are extremely poor, but response to medium skiffing and other lighter forms of skiff will depend upon the clone or the *jat* as well as their growing conditions. The statement is open to the criticism that data collected in this experiment over a period of three years did not eliminate the effect of seasons on yield. While this is so, observations made in the shade × nutrient × clone trial at Tocklai on a different context (cf. Ann. Rep. for 1969-70, p. 45) tend to confirm the validity of the above statement.

The clonal bushes of the shade × nutrient × clone experiment were not pruned in the 1967-68 cold weather but plucked continuously all through the 1968 season. The bushes were pruned in December 1968 and tipped and plucked in 1969. Clone and treatment-wise plucking records were maintained for both the seasons. Comparison of the yield data for the unpruned (1968) and pruned (1969) seasons showed that all the 26 clones in the plot shaded with *A. chinensis* trees, with and without NPK fertilizer, produced more yield in the unpruned year, the average increase being 30-40 per cent over the pruned year. In the unshaded and unmanured plots only 8 out of the 26 clones showed some yield increase in the unpruned year, but the average for the 26 clones registered a decrease of 5 to 15 per cent. A good stand of shade, therefore, appears to be a crucial factor for the success of any lighter forms of skiff and this must be linked with the higher moisture status of the soil during the dry winter months under a good stand of *A. chinensis* trees than in the open.

Thus it appears that vigour of the bush, its growing conditions, proneness of the area to drought and possibly the degree of control of pests, determine the response of tea fields to medium and lighter forms of skiff.

Seasonal Dormancy in Tea

Experiments to test the commercial possibilities of breaking winter dormancy of tea bushes in N. E. India were continued during the year in collaboration with the Agriculture Department (cf. Ann. Rep. 1968-69, pp. 61-62; 1969-70, pp. 44-45). Fuller details of these experiments are reported under Agriculture.

Spraying of unpruned and pruned tea bushes with solutions of gibberellic acid has now shown distinct commercial possibilities for advancing bud break by about a month.

TEA MITES

Life system of the Scarlet mite : Seasonal population cycle of the Scarlet mite (*Brevipalpus phoenicis* (Geijskes) on 15 year old bushes in Darjeeling and in the plains of the Dooars indicate that in the high altitude (above 1000 meters), the mite numbers are lesser per unit area of the leaf than in the plains. One mite/sq cm of the leaf surface causes an effective damage in high altitude, whereas in the plains two mites sq cm of the leaf caused the same intensity of damage. The damage causing ability of the mite, therefore, varies according to the altitude (Fig 1).

Inspite of the difference in distribution, mite populations both in the plains and in the hills, showed an upward trend from March, reaching peaks during May and June. The peak was more conspicuous in the plains than in the hills. During the cold weather, populations went down considerably, but the critical levels were maintained in all the habitats.

During the peak period, the mite laid, on an average, 2-3 eggs in a day, against one egg a day during the cold weather. The numbers of eggs laid and the duration of life-cycle in different seasons were consequential in maintaining the population at different levels.

Effect of Nitrogenous manure on the incidence of Scarlet mite : Using a split plot design, with five clones, and three manurial treatments in three replicates, the influence of the manurial rates on the incidence of the mite was assessed. The clones used were TV 1, TV 2, TV 3, TV 4 and TV 5 : the manurial treatments were o kg, 55 kg, 100 kg and 165 kg of Nitrogen in the form of sulphate of ammonia to the hectare.

The manurial treatments *per se* had no significant influence in depressing the mite numbers, nor the interactions between Nitrogen and clones were formally significant. Clonal susceptibility to the mite however varied, with TV 3 suffering least from the mite attack

Clonal susceptibility to Red spider : The inter-clonal variation in the red spider infestations was studied initially from the egg laying capacity of the mite on Tocklai clones TV 1 to TV 9, at 27°C ± 3 (80°F ± 37) with 80% ± 5 relative humidity in the laboratory. This range of temperature and humidity was most conducive to egg laying. The results (Table 1) show that although the egg laying

Table 1. Egg laying by red spider on different clones in the laboratory

Clone	Oviposition days	Number of eggs laid per day
TV 1	13	4
TV 2	16	5
TV 3	18	5
TV 4	14	5
TV 5	13	6
TV 6	21	4
TV 7	22	4
TV 8	19	5
TV 9	19	4

period was protracted on some clones and shortened on others, it did not significantly affect the average daily production of eggs. It may well be possible that leaf characteristics of the clones directly influenced the oviposition period, but their influence on the quantum of eggs laid was apparently negligible.

Clonal resistance to Red spider : Preliminary analyses of the suspected resistance of the Nagrakata clones, R/D3/20, R/D3/27 and R/D3/44 were made from the seasonal incidence of the mite on these hybrid clones, compared to that on the standard Tocklai clones in the same plot. The three Nagrakata clones had no, or significantly less, red spiders than the Tocklai clones and the difference was maintained all the year round. The leaf characteristics of these clones, particularly

Fig 1. The scarlet mite of tea

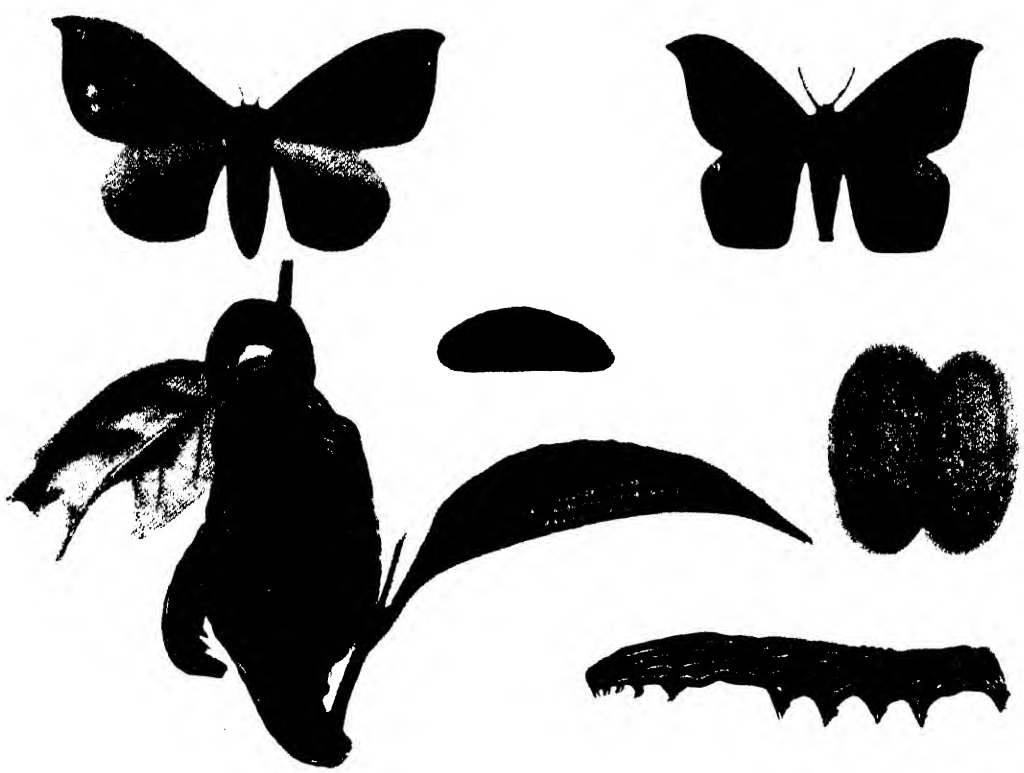


Fig 2. Different stages of the development of *Andraca bipunctata* Wlk

their extreme hairiness and roughness, might have prevented the mite build up. The present study did not, however, indicate for how long would these clones remain resistant to mite build up.

Weedicides and Red spider incidence : Since some weeds in tea areas serve as alternate hosts for red spider, the possible side effects of chemical weed control on the incidence of the mite was thought to be of consequence. Weed control with Gramoxone and Karmex, at their standard dilutions, actually helped in reducing the mite numbers by killing the weeds on which the mites were thriving.

Effect of fungicides on mite complex : The possible side effects of fungicides on the incidence of different mite species were assessed in plots treated with Blitox and Nickel chloride, each at 0.50 kg in 200 litres of water. Spraying was done at ten day intervals all the year round. Nickel chloride had no perceptible effect on mite numbers, but Blitox enhanced greatly red spider numbers, and pink and scarlet mites to a certain extent: its influence on purple mite was obscure. The reasons for the diverse behaviour of the mite species with the fungicides were not immediately clear, but these observations are being continued.

BUNCH CATERPILLARS ON TEA

Ecology of the caterpillar population : Population fluctuations of the bunch caterpillars (*Andraca bipunctata* Wlk) were studied using life-table techniques. The principal natural mortality factors at every stage of the development of the caterpillars were identified (Fig 2).

The egg laying capacity of the moths in different seasons was responsible for the initial variation in the caterpillar numbers in different generations : the natural mortality of the caterpillars appeared to have regulated the overall population growth. The first and the second instar caterpillars were parasitised by a species of Tachinid fly. The adult fly laid eggs on the surface of the caterpillar body and the maggots on emergence penetrated deep into caterpillar body. The parasitised caterpillars became sluggish and eventually died. The third, fourth and the fifth instar caterpillars were not parasitised, but were infected by *bacillus*. The close physical aggregations amongst these three late instar caterpillars were conducive to the rapid spread of the infection, which the first two instars avoided by being non-aggregating.

The caterpillar numbers declined below their operative levels when the *bacillus* infections became widespread. This partially prevented the outbreaks of these defoliators in some years. The influence did not however last long because of the migration of the moths into tea from their alternate hosts outside tea. The newly migrant moths quickly initiated the population cycle on tea.

SHADE TREE PESTS

Shade tree canker : A biennial peak in the larval populations of *Agrilus beesoni* Obenberger was noticeable. The first peak occurred during January to March and the second during September to December. The first peak was of higher magnitude and had a large population of advanced larval instars in it. By March, these larvae entered into their pupal stages, thus causing a sharp decline in larval population after March. The new generation of adults appeared during April to July, and soon after emergence they started laying eggs. The September peak had a mixed larval population because the beetles did not lay their eggs all at the same time.

Pest Survey : The abundance of the following pest species on the shade trees mentioned was of significance. These pests were recorded only in negligible numbers in the past two years.

1. *Albizzia odoratissima*—Membracids, Lymantriid caterpillars and Orange beetles.
2. *A. chinensis*—*Agrilus* and Orange beetles.
3. *A. lebbeck*—Psyllids and Green caterpillars.
4. *Indigofera teysmanii*—Membracids.

NEMATODES

Seasonal abundance of pathogenic nematodes in soil : The population of pathogenic nematodes started increasing from March, reaching

a peak during May to July. During August to October, the population was well stabilised and fluctuated only a little. From November onwards, the population started declining and was maintained at a low level during the cold weather.

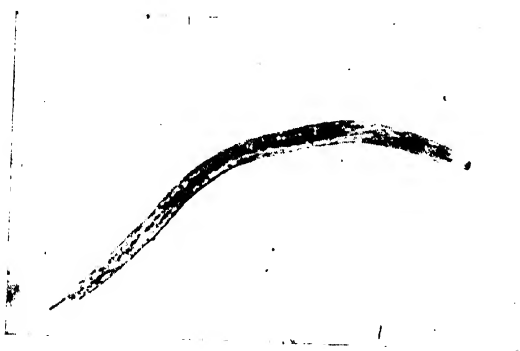


Fig 3. A typical pathogenic nematode

The numbers of pathogenic nematodes (Fig 3) in the soil are determined by (a) the availability of alternate host plants and (b) their ability to survive in the absence of these host plants. The increase in nematode numbers coincided well with the appearance and spread of the weeds during monsoon. In the absence of these weeds, the nematodes did survive in the soil, but their reproductive rates were reduced considerably.

Effect of soil insecticides and weedicides on nematode numbers : The possible effects of chemicals, other than nematicides, were evaluated from the counts of nematodes in plots treated with DDT 50% WP, Endrin 20 EC and the weedicide 2,4-D at their respective standard dilutions. In no case, did these chemicals cause a significant reduction in nematode numbers. 2,4-D, however, caused an indirect reduction by killing the weeds that supported the nematodes : it had no effect when sprayed in weed-free plots.

Distribution of nematodes in the soil : The basic reason for the wide variation in nematode numbers in the routine soil samples from the same area was found in the patchy distribution of the nematodes in the soil (Fig 4). The analysis was based on a series of sequential samples, drawn from an area of 9.29 sq m (100 sq ft) with sampling units of .093 sq m (One sq ft). Many units were without any pathogenic nematodes at all, and in others their numbers varied from low to very high. The practical importance of this finding is clear. Unless the samples are drawn truly at random from various parts of a proposed nursery site, some samples might show heavy concentration of nematodes, while others may be absolutely free of them. This might give a wrong picture of the nematode situation in a particular area.

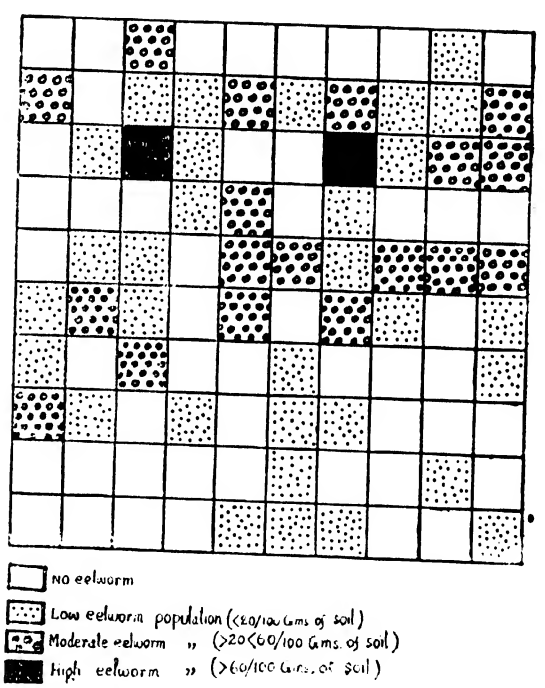


Fig 4. Spatial distribution of eelworms in the soil

Nematode Survey : In course of the routine survey, a new cyst forming nematode, *Heterodera* sp., has been recorded for the first time from North-East India. The species has been isolated from

Fig 5. A Section of the field Laboratory showing the cubicle for rearing different species of nematodes

the tea soils of widely separated areas in the Dooars and Upper Assam. In the absence of a continuous distribution, the otherwise formidable cyst forming nematode does not pose an immediate threat to tea. Efforts are, however, being continued to find out its relative abundance and distribution in different parts.

Pathogenicity of Root-Knots : The pathogenic or disease causing effect of the root-knot *Meloidogyne incognita* (Chitwood) was tested by growing young shade tree seedlings (*Albizzia* spp.) in sterile soils, artificially inoculated with pathogenic second instars of the nematode. The pathogenic forms moved into the roots, and in about two weeks' time, produced the characteristic galls on the root surface. The susceptibilities of all the *Albizzia* species to this nematode suggest that if the infested seedlings are planted out, they might act as foci for nematode infestations to young tea.

Mycology Department

Red Rust

A significant chemical control of red rust is achieved by usually spraying a standard copper formulation during the fruiting period of the alga (causal organism) at 0.25% concentration with hand operated sprayers using approximately 3 kg of the product per hectare. When it is sprayed with a power sprayer, the application is made at the rate of 2.5 kg of the product per hectare. Application of copper fungicide gave a very efficient control when the application was made at monthly intervals for 4 rounds in 1969. The time to start the application varies from year to year depending on climatic conditions, because the spraying must be undertaken after the organism starts its growth.

In 1970/71, studies were undertaken to see the effect of spraying Blitox, a standard copper formulation, at half the recommended dosage on the red rust affected bushes during the actively sporulating period (May to July). Spraying was done for 3 and 4 rounds using both power (JAWAN) as well as hand operated (bakpak) sprayers. The treatments were as follows :

1. Blitox at standard dose*, 3 rounds at monthly interval
2. Blitox at standard dose*, 4 rounds at monthly interval
3. Blitox at half the standard dose, 3 rounds at monthly interval
4. Blitox at half the standard dose, 4 rounds at monthly interval
5. Control, unsprayed

*i) Standard dosage for hand operated knapsack type: The main aim is to thoroughly drench the bush with the spray fluid, concentration of which is 0.25%.

The fungicidal requirement varies with the size of the bush and is approximately 2.5 to 4 kg/ha.

ii) For power sprayer: The standard dose is 2.5 kg/ha with sufficient water to cover the bushes efficiently.

The experiments were laid out on two different estates. In one experiment fungicidal applications were made with a hand operated sprayer while in the other, with a Fontan type of sprayer. In both the trials the treatments were replicated four times.

It was seen that, application at half the dosage gave appreciable reduction of the disease in both the experiments. It would be interesting to see if the addition of a sticker would result in better control.

In a screening trial, Panacide (Murphy chemicals), BAS 3050 (Badische & Soda Fabrik Ag.), Benlatea systemic fungicide (Du Pont de Nemours & Co.) and Brestanol (Hoechst Pharmaceuticals Ltd.) compared favourably with Blitox in reducing red rust sporulation. The results are given in Table 1.

Table 1. Effect of different chemicals on the control of red rust

Treatments	Mean degree of incidence per plot
1. Blitox 0.25%	15.0
2. Panacide 5 ml/2l	21.8
3. BAS 3050 0.25%	21.8
4. Benlate 6 g in 10 l	29.0
5. Brestanol 0.25%	14.8
6. Control	54.8
C.D. at p 0.05	15.2
C.V. %	37.5

Thorny Stem Blight

In 1965 an experiment was laid out on an estate in the Darjeeling district, known to be severely affected by the disease. The object of the trial was to test the efficacy of some chemicals in preventing infection through the pruning wounds when applied as a post pruning measure immediately following a heavy prune. The following treatments were applied to pruned bushes in randomised plots, replicated six times.

Treatments

1. Sprayed copper fungicide (0.25%) and then applied Indopaste onto the pruning cuts with a brush.
2. Indopaste alone applied as above (No copper spraying).
3. Fungicide 6422 (Santer A) applied as above.
4. Copper fungicide 1%, sprayed
5. Nickel chloride 1%, sprayed
6. Ziram 0.25%, sprayed
7. Control (no treatment).

The area was kept under observation during the period and the progress of the disease was noted. The area was finally assessed during 1970/71 and the degree of development of the disease is shown in Table 2.

Table 2. Effect of post pruning treatment on the incidence of throny stem blight

Treatments	Incidence of disease per plot
1. Copper fungicide + Indopaste	8.2
2. Indopaste	9.7
3. Fungicide 6422	9.5
4. Copper fungicide 1%	15.0
5. Nickel chloride 1%	14.0
6. Ziram 0.25%	14.3
7. Control	17.3
C. D. at p= 0.05	2.4
C. V.%	16.2

It is evident that Indopaste and Fungicide 6422 have significantly prevented infection to the same extent. The additional spraying of a copper fungicide prior to application of Indopaste did not offer significantly better protection as compared to mere application of Indopaste and 6422.

Fungicide 6422, however, edges out Indopaste in one aspect. It does not become a hard solid in cooler temperatures prevailing in Darjeeling area during the pruning season. It is, therefore, easier to apply. Further, it can be detected from a distance because of its distinguishing yellow colour.

Observations were continued in the plots receiving NPK treatments in the trial conducted by the Darjeeling Advisory Branch. No significant reduction on the incidence of thorny stem blight in any of the treatments was noticeable.

Another experiment was started during 1970 to study the effect of foliar spraying of a systemic fungicide (Benlate) in mitigating thorny stem blight infection.

Black Rot

Panacide (Murphy Chemicals, England), Benlate (Du Pont de Nemours & Co.), Brestanol (Hoechst Pharmaceuticals Ltd.) and BAS 3050 (Badische & Soda Fabrik Ag.) were tested in the field for their efficacy to control black rot infection. None of these formulations gave encouraging results.

Black Rot

In the trial initiated in North Bank, Assam, in the year 1968, observations were continued to see the overall effect on yield and disease incidence in plots sprayed with Blitox in two rounds at fortnightly interval in May-June during the first two years (1968 and 1969). No spray was given in 1970.

It was observed that in 1970 the treated plots showed slightly more infection of black rot compared to the previous season, but still the plots had 85 to 87 per cent lesser infection than in the control (untreated) plots. It was, however, noted that reinfection was taking place by means of leaf contact from the guard lines.

The yields maintained the steady increase noted earlier. The yield data for the previous two seasons are also included in Table 3 for comparison. The yield data for each plot were collected by our North Bank Advisory Branch during the plucking rounds.

The results emphasize once more the beneficial effects of long term spraying in case of a disease like black rot which persists in the bushes from season to season and destroys the maintenance leaves during the actively growing season.

Table 3. Effect of Copper fungicide spraying on black rot control
(Average of 6 replicates)

Treatments	1968		1969		1970	
	Yield in kg green leaf per 40 bushes	% increase over control	Yield in kg green leaf per 40 bushes	% increase over control	Yield in kg green leaf per 40 bushes	% increase over control
1. Blitox 1 in 400 (approx. 4.5 kg/ha) with knapsack sprayer	29.5	9.7	34.1	18.8	36.9	21.4
2. Blitox 2.5 kg/ha with Fontan sprayer	29.6	10.0	32.6	13.6	35.7	17.4
3. Blitox 4.5 kg/ha with Fontan sprayer	29.0	7.8	32.8	14.3	35.7	17.4
4. Control (No spraying)	26.9		28.7		30.4	
C. D. at p 0.05	2.0		1.8		1.5	
C. V.%	5.7		4.5		3.6	

In an effort to control black rot with power sprayer of the Fontan type, it was observed that even by dispersing the standard fungicide in 200 litres of water per hectare, the same degree of control as achieved by pressure retaining knapsack sprayers is not attainable. However, by using 400 litres per hectare more efficient control was obtained.

Purple Root Rot

An experiment was laid on the North Bank to study the chemical control of purple root rot in the year 1967 (vide Annual Report 1969-70, p. 52).

No death was reported from the treated or untreated plots during the season.

Shade and Nutrients Experiment BAS 204

The experiment was laid out by the Botany Department at Murmuria T. E. in the year 1966 to study the effects of removal of shade and applications of nutrients. Initially the whole area was well-shaded with *Albizzia odoratissima*. The shade trees were then removed from some plots and manures were applied to conform to the following treatments.

112 kg N/ha with and without shade
224 kg N/ha with and without shade
224 kg N, 45 kg P, 90 kg K/ha with and without shade

The Mycology Department assessed the degree of incidence of important leaf and stem diseases like black rot, red rust and *Poria* stem disease in the treated plots since 1966.

Black rot was not significantly influenced by shade or nutrient in the first three years. In the fourth year, however, the application of NPK in the unshaded area resulted in lesser infection by black rot though no such trend was noticeable in the shaded plots. Moreover, shaded plots started to show slightly more infection than in the unshaded ones.

Red rust development was not significantly affected in the first year either by shade or nutrients. But from the second year onwards, development of the disease significantly increased in the unshaded plots irrespective of manurial treatments.

Poria stem disease had significantly increased in the plots wherefrom the shade was removed.

Aerobiology

During 1970, a continuous automatic Hirst spore trap was commissioned for spore trapping. The spore trap samples 9 litres of air per minute through an orifice 2 mm broad and 14 mm long. The slide moves upwards of 2 mm per hour by a clock work mechanism. Detailed studies are continued. From the discharge pattern observed between March and July, it is seen that the red rust spores are discharged during the day, peak period being around the mid-day. Black rot type spores (colourless basidiospores) are found to have peak concentration around 4 to 6 a.m.

Pesticide Department

Screening of Pesticides

The department worked mainly on the evaluation of new pesticides during the year for the control of various mite pests, jassids, looper caterpillar, cockchafer and red rust in different commercial tea estates.

Acaricides

Prophylactic Spraying

It had been established beyond doubt that prophylactic spraying can bring down the incidence of red spider and other mites considerably. Further prophylactic trials with new acaricides were carried out against red spider during the season 1970/71. The results on the percentage reduction of mites over control after two months of application are presented in Table 1 and acaricides which showed promising results only, are included.

Table 1. Efficacy of new acaricides as prophylactic treatments

Trials	Treatments	Rate l/kg per ha	Percentage reduction of Red spider population over control
I	Azodrin 60 WSC	1.25	97
	Acarthane	1.25	87
	Delnav	1.25	82
	Ethion	1.25	95
II	Acrex 30 E.C.	2.50	94
	Hoe 6012	2.50	93
	Hoe 6021	2.50	89
	Plictran	2.50	85
	Tedion	1.25	94

Azodrin (Trial I), a new phosphatic acaricide, @ 1.25 l/ha was found to be at par with our recommended acaricide Ethion.

But in trial No. II, only the higher doses i.e. 2.50 l/ha of Acrex, Hoe 6012, Hoe 6021 and Plictran were equitoxic to Tedion at 1.25 l/ha.

Palliative Spraying

Palliative trials were carried out in areas where the infestation of red spider was moderate and uniform. Most of the acaricides used in these trials were new formulations. The treatments were applied only once with 'Jawan' power sprayer having an under the elbow discharge lance. The results are shown in the table No. 2 according to their order of merit.

Table 2. Efficacy of new acaricides as Palliative treatments

Trials	Treatments	Rate l/kg per ha	Observations after 1 month: No. of living population of Red spider (Mean of 3 replications)	Observations after 1 month: Percentage reduction over control
I	Acarthane	1.25	6.67	96
	Exptl. acaricide	,,	15.67	90
	Dikar	,,	17.67	89
	Imidan	,,	18.33	88
	Furadan	,,	23.00	85
	Lovozal	,,	24.33	84
	Zolone	,,	47.00	80
	Acrex	,,	51.33	78
	Least significant difference at P=0.05		31.64	—
	C. V. %		64.07	—

Trials	Treatments	Rate l/kg per ha	Observetions after 1 month: No. of living population of Red spider (Mean of 3 replications)	Observetions after 1 month: Percentage reduction over control
II	Tedion	1.25	8.2	94
	Plictran	2.25	13.2	90
	Ethion	1.25	20.2	86
	Kelthane	,,	23.2	84
	Plictran	1.125	25.7	82
	Morocide	1.25	30.7	79
	Plictran	0.5625	50.5	65
	Least significant different at P=0.05		18.89	—
	C. V. %		51.77	—
III	Tedion	1.25	2.67	99
	Azodrin	,,	13.33	97
	Acrex	2.5	15.67	97
	Malathion ULV	1.42	18.33	96
	Acrex	1.25	59.00	88
	Hoe 6012	1.25	104.67	78
	PP 511	,,	156.67	68
	Gardona	,,	194.67	60
	Zolone	,,	196.67	60
	Furadan	,,	242.33	50
	Hoe 6021	,,	295.67	39
	Least significant difference at P=0.05		8.93	—
	C. V. %		44.46	—

In trial I, Acarthane gave the highest percentage reduction amongst the treatments and at the same time equitoxic to all the treatments except Zolone and Acrex.

In trial II, all the treatments were superior to lowest dose of Plictran @ 0.565 and there was no significant difference between Plictran @ 2.25 kg/ha and 1.125 kg/ha.

In trial III, Tedion was found to be the best Azodrin @ 1·25 l/ha, Malathion ULV @ 1·42 l/ha and Acrex @ 2·5 l/ha were equitoxic and significantly better than all other treatments.

Acaricides/Insecticides

Combined Spraying Trials

The combined infestation of various pests can be effectively controlled by single applications of different pesticides mixed together at comparatively lower doses. This was ascertained on the results of three consecutive years' trials presented in the annual report 1969/70. The results of the investigations on palliative treatment made in 1970/71 are presented in Table 3.

The results show that mixtures of two or more acaricides or acaricides/insecticides can effectively control mites and insects by a single spray even at much lower doses than the individual pesticide at the recommended dose, and bring down the cost of application considerabley.

Insecticides

Jassids

Jassids can cause considerable damage to tea, particularly during the early season. Since the banning of the chlorinated hydrocarbons, such as DDT, Endrin, Dieldrin etc., it has become urgently necessary to search for new but potent insecticide with low mammalian toxicity for the control of this pest. With this object in view, a small scale field trial was initiated with five new pesticides in an area of clonal plantation where the infestation of jassid was moderate. Altogether two applications were made at an interval of 15 days with a power sprayer having the discharge lance under the elbow (Jawan).

Table 3. Different combination of compounds (acaricides/ insecticides) used against combined infestation of mites and insects (red spider, scarlet, purple, scales and thrips)

Trials	Treatments	Rate l/kg per ha	Observation after 1 month (Percentage reduction of population over control)				
			Red spider	Scar-let	Pur-ple	Scales	Thrips
I	Ethion + Kelthane	0.5 + 0.5	100	99	99		
	Tedion + Morocide	0.5 + 0.5	100	98	97		
	Tedion + Trithion	0.5 + 0.5	100	96	99		
	Tedion + Kelthane	0.5 + 0.5	100	96	98		
II	Ethion + Kelthane	0.375 + 0.375	100	99	100		
	Tedion + Morocide	0.375 + 0.375	100	92	99		
	Tedion + Trithion	0.375 + 0.375	100	98	100		
	Tedion + Kelthane	0.375 + 0.375	100	99	99		
III	Tedion + Malathion + Thiodan	1.25 + 1.875 + 0.625		95		94	100
	-do-	0.75 + 1.25 + 0.3125		91		97	100
	Ethion + Malathion + Thiodan	1.25 + 1.875 + 0.625		97		97	100
	-do-	0.75 + 1.25 + 0.3125		95		96	90
	Morocide + Malathion + Thiodan	1.25 + 1.875 + 0.625		98		99	100
	-do-	0.75 + 1.25 + 0.3125		96		97	96
	Kelthane + Malathion + Thiodan	1.25 + 1.875 + 0.625		100		99	100
	-do-	0.75 + 1.25 + 0.3125		97		98	94
	Trithion + Malathion + Thiodan	1.25 + 1.875 + 0.625		96		99	100
	-do-	0.75 + 1.25 + 0.3125		94		97	100

Thiodan, Sumithion, Gardona and Phosvel @ 1.25 l/ha gave satisfactory control of the pest and the percentage kill being 100, 97, 97 and 94 respectively. Dursban which was tried @ 2.5 l/ha also gave a kill of 94% one month after the 1st application. These insecticides have not yet been granted an acceptable residue tolerance and hence, one round of plucking should be discarded when these are used on tea in plucking.

Looper

It has been found through repeated trials during

1970, that Sumithion 50 E.C. @ 1.25 l/ha was equitoxic to Thiodan 35 E.C. @ 2.5 l/ha and has been recommended for the control of looper caterpillar. When Thiodan and Sumithion are used on tea in plucking, one round of plucking is discarded.

Cockchafer

Although Telodrin and Thiodan have been recommended for the control of Cockchafer grubs, particularly in the young clonal plantations in the Dooars, the Pesticide Department has been in search of more effective control measures for the pest. As such, field trials were initiated and 'management practice' as one of the treatments, was introduced along with other new chemical treatments.

In this practice, the planting pits were dug 45 cm deep and 45 cm wide with soil loosened a further 15 cm at the bottom of the pit. While planting, the soil round the *dhela/bheti* was rammed in firmly and 30 g superphosphate was applied per plant mixed with the soil dug out from the planting pits. Only plants carrying 18 leaves or more were selected for planting. In the other treatments including the control, pits were dug 30 cm deep and 30 cm wide and the plants used had less than 18 leaves and no superphosphate was used at the time of planting.

It is interesting to note that the 'management practice' tried out, certainly helped in reducing the damage by cockchafer grubs.

Fungicides

Red rust

Recent studies at Tocklai on the spore dispersal pattern of red rust have shown that its spores are dispersed into the atmosphere not only during April/May, but continue for a longer period up to September/October, though in smaller numbers.

To this effect, intensive field trials have been conducted with various copper fungicides. The results confirmed that four rounds of copper spraying (recommended copper oxychloride or cuprous oxide @ 2.5 kg/ha) at an interval of two weeks from the middle of May or any time after the disease is seen till the end of June, can considerably check red rust incidence and spread.

Taints of Made Tea due to Pesticides

PP 511, Sumithion, Kocide 101, Hoe 6052, Lovozal, Dikar, Acarthane, Delnav, Furadan, Plictran, Dithane M 45, Colloidox, Difolatan, Dursban, Phosvel, Tranid, Sevin, Miltox, Imidan, BAS 22601 and Acrex were tested to find out whether they taint made tea when sprayed at recommended doses. Of all the chemicals only Phosvel imparts taint to made tea, whereas there is suspicion of taint in case of Difolatan.

Residue evaluation

Field trials were conducted during dry weather to evaluate residue of Trithion.

Certification of Pesticides and Herbicides

During the year 10 new products were received for official testing. Certificate of approval for 6 products were issued and 17 Certificates were renewed.

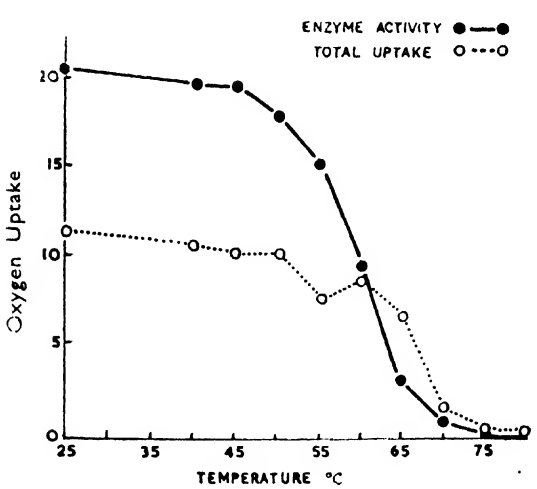
Biochemistry Department

Keeping Quality of Made Tea

Changes in the chemical composition of clonal Orthodox and C.T.C. teas stored upto 24 weeks at room temperature (19° – 30°C) in an air-conditioned room (19° – 23°C) and in ice-box (0-5°C) were reported in the Annual Report for 1969-70, p. 62. Some of these teas, kept in storage for 92 weeks, were tasted by the Tocklai Taster and were found to have "gone off". These "gone off" teas were then analysed for chemical constituents. No changes in TF, TR, Cream Index etc. could be detected between tea samples stored for 24 and 92 weeks, but moisture and fatty acids increased, while soluble solids and soluble nitrogen decreased in samples stored for 92 weeks.

The quantity of fatty acids of the 92 weeks samples was found to be more than double of the 24 week samples, suggesting that rancidity ("going off") of the former set of samples was caused by an increase in the concentration of fatty acids. Other experiments on storage have shown that oxidation plays an important role in the deterioration of stored teas and this could be prevented for a long time by storing in an inert atmosphere.

Further study on the keeping quality of tea dried at different temperatures is under progress.



ig I. Determination of Enzyme Activity and Total Oxygen uptake of Fresh Leaf Exposed to Various Temperatures

Enzymeless Tea

Earlier observations suggested that continuance of enzyme activity in made tea, though at a much reduced rate, could be one of the causes for the "going off" of tea in storage. An experiment was carried out by autoclaving fermented tea leaf particles to destroy enzyme activity, drying them in the usual way, and then determining the biochemical constituents and organoleptic properties of the teas made from steamed, fermented leaf.

Fermented tea particles of Tocklai clones 19/29/13 and 20/23/1 were steamed in an autoclave for five minutes and in a pressure cooker for two minutes, respectively. The steamed and normally fermented leaf particles and corresponding made teas were analysed for enzyme activity, residual polyphenols, theaflavins, thearubigins and caffeine. The residual enzyme activity was estimated in the presence and absence of added catechins. The made teas were tasted and evaluated by the Tocklai Taster.

No oxygen uptake was found in the fermented leaf and corresponding made teas when the fermented leaf of clone 19/29/13 were authoclaved for five minutes. The residual polyphenols were higher in the steamed made teas than in the normal teas. Estimation of theaflavins and thearubigins supported the above findings. It is likely that theaflavins and thearubigins are hydrolysed to the initial constituents by exposure for five minutes to pressurised steam. The caffeine percentage in the autoclaved teas was lower than the normal teas. The Taster considered these teas inferior to the control.

In clone 20/23/1, steamed fermented leaf particles (in pressure cooker for two minutes) retained 50% per cent of the enzyme activity of normally fermented leaf. No difference was obtained between the residual polyphenols of steamed and normal teas. The estimation of theaflavins and thearubigins supported the above results. It appears that two minutes in a pressure cooker had much less effect on the chemical constituents than five minutes in an autoclave.

The analytical results and Taster's valuations are summarised in Tables 1 and 2.

Table 1. Enzyme activity (μl/mg/hr) and total oxygen uptake (μl/mg/2hrs) at 32°C in distilled water medium

Clone	Sample	QO_2 (μl/mg/hr)		Total oxygen uptake (μl/mg/2hrs)	
		without catechin	with catechin	without catechin	with catechin
19/29/13	1. Green leaf	17.88	—	9.52	—
	2. Rolled leaf (C.T.C.)	14.76	13.50	7.19	8.48
	3. Fermented leaf	2.57	5.25	1.75	2.43
	4. Fermented and steamed for 5 min in autoclave	nil	nil	nil	nil
	5. Made tea (C.T.C., normal)	1.05	1.06	1.42	1.77
	6. Made tea (C.T.C., steamed for 5 min)	nil	nil	nil	nil
20/23/1	1. Green leaf	19.82	—	7.95	—
	2. Rolled leaf (C.T.C.)	10.30	16.74	3.73	5.97
	3. Fermented leaf	1.16	4.74	1.51	2.12
	4. Fermented leaf steamed for 2 min in pressure cooker	0.74	3.72	1.10	2.57
	5. Made tea (C.T.C., normal)	1.40	1.63	1.13	1.46
	6. Made tea (C.T.C., steamed for 2 min)	0.72	0.57	0.76	0.75

Table 2. Theogallin (TG), epicatechin gallate (ECG), epigallocatchin gallate (EGCG), Theaflavins (TF), Thearubigins (TR), caffeine content and Taster's valuation of clones 19/29/13 and 20/23/1

Clone	Sample	TG%	ECG%	EGCG%	TF%	TR%	Caffeine %	Valuation Rs./kg
19/29/13	Made tea (C.T.C., normal)	0.38	0.64	0.64	1.44	18.33	3.42	9.00
	Made tea (steamed for 5 min in autoclave)	0.52	1.00	0.73	1.26	15.38	2.33	5.00 (bitter)
20/23/1	Made tea (C.T.C., normal)	0.73	0.56	0.94	2.11	13.48	4.25	7.50
	Made tea (steamed for 2 min in pressure cooker)	0.72	0.53	0.87	2.11	13.14	3.93	7.00

Determination of Enzyme Activity and Total Oxygen Uptake of Fresh Leaf exposed to Various Temperatures (in collaboration with the Senior Botanist).

Plucked shoots of clone 19/29/13 were dipped for 2 minutes in water at various temperatures and enzyme activity and total oxygen uptake of the treated leaves were determined. These results are shown graphically in Fig 1.

It was noted that the leaf becomes flacid when exposed to temperatures higher than 55 C.

In another experiment enzyme activity and total oxygen uptake were determined by dipping the leaf at 50 C for 5, 10 and 20 minutes. No appreciable loss in enzyme activity and total oxygen uptake was observed at 5 min, and a slight loss at 10 minutes but at 20 minutes, the readings were same as those obtained by dipping leaves at 55 C for two minutes. These results are given in Table 3.

Table 3. Enzyme activity (QO_2) and total oxygen uptake, leaf dipped in water at 50 C for 5, 10 and 20 minutes

Temperature of water bath	Time of dipping	Enzyme activity (QO_2 μl/mg/hr)	Total oxygen uptake (μl/mg/2hrs)
Control	- -	20.31	11.37
50 C	5 min	20.70	10.00
,,	10 ,,	18.70	8.75
,,	20 ,,	15.28	7.54

Miscellaneous Experiments

(a) **Moisture determination of tea leaf by N-Foss meter**

The moisture percentage of whole fresh leaf, whole withered leaf, cut pieces of fresh and withered leaf, rolled and C.T.C. leaf, and fermented leaf was determined by using a N-Foss infra-red mois-

Table 4. Moisture determination of tea leaf particles by N-Foss type moisture meter

Sample	Quantity of leaf	Per cent moisture by N – Foss	Per cent moisture by oven	Difference between the two methods (Per cent)	Time of exposure in N – Foss meter for complete removal of moisture
Fresh leaf, whole	5 g	77.05	78.00	0.95	45–55 min
	,,	79.80	79.97	0.17	
	,,	77.50	78.44	0.94	
Fresh leaf, cut into pieces	5 g	76.10	76.74	0.64	
	,,	78.40	78.90	0.50	45–55 ,,
	,,	76.10	76.74	0.64	
Withered leaf, whole	5 g	70.10	69.72	0.38	
	,,	69.40	69.70	0.30	45–50 ,,
	,,	70.50	70.60	0.10	
Withered leaf, cut into pieces	5 g	69.40	69.70	0.30	45–50 ,,
	,,	70.40	69.50	0.90	
Rolled leaf, fermented	5 g	67.10	68.11	1.01	
	,,	65.50	66.05	0.55	40–45 ,,
	,,	68.60	67.60	1.00	
C. T. C. leaf, fermented	5 g	69.80	69.95	0.15	
	,,	68.90	68.50	0.40	35–40 ,,
	,,	67.40	67.30	0.10	

ture meter with the lamp (150 watt) at the third hole from the bottom. The moisture content was also determined by the standard oven method. The variation in the moisture content between the two methods was found to be less than 1 per cent as can be seen from Table 4. However, it should be noted that the time taken for complete removal of moisture from tea leaf by whatever method used, is based on leaf-size and season.

(b) **Analysis for TF ane TR on graded samples collected from Socklatinga T. E.**

A few samples of graded tea (Orthodox manufacture) obtained through the kind courtesy of Socklatinga T. E. were analysed for TF and TR. The results in decreasing order of TF are given in the Table 5.

Table 5. Chemical constituents of graded tea samples from Socklatinga T.E.

Graded samples	TF %	TR %	Brightness %	Total colour
O F.	0.76	15.04	16.80	4.46
T.W.(tea waste)	0.74	12.64	22.10	4.22
Dust	0.72	15.46	16.71	4.49
Fannings	0.70	14.83	13.24	4.72
F.B.O.P.	0.65	14.40	14.40	4.34
Coarse Dust	0.64	15.00	12.67	4.44
F.O.P.	0.64	10.77	19.00	3.12
B.O P 1	0.59	12.88	14.30	3.91
Fine	0.58	11.01	17.00	3.12
O.P.	0.56	10.45	18.39	2.72
B. P.	0.54	9.74	16.84	2.97
G.B.O P.	0.43	13.20	28.15	3.59
Coarse	0.40	10.31	13.54	3.00
B. T. (stalk)	0.38	7.27	12.12	2.06

Further experiments on graded tea samples are in progress.

(c) **Analysis of samples**

A total of 486 samples from Research Engineering Department, Botany Department and Manufacturing Advisory and Tea Tasting Department, and different tea estates were analysed for TF, TR and moisture content during the year.

Technicon Auto-Analyser used for the determination of theaflavins Total colour and Total Polyphenols

Zeiss Spectro photometer used for spectral analysis of Tea infusions

(d) **Moisture Meters**

16 moisture meters from various tea estates were calibrated during the year.

Manufacturing Advisory & Tea Tasting Department

EXPERIMENTS AT TOCKLAI

Leaf Carriage : It was observed (Ann. Rep., 1969-70. p. 65) that use of a humidified trailer for transporting leaf helped to keep the leaf cool which in turn gave better quality tea.

The experiment was repeated in 1970 again from July to October, when the ambient temperatures were very high.

On each occasion tea made from leaf transported in the humidified trailer was superior to tea made from leaf transported in the ordinary trailer.

These teas were sorted and then tasted by the Tocklai Taster as well as Panels of Tasters in Calcutta. From the valuations given by the Tocklai and Calcutta Panels of Tasters and taking the mean difference in value thereof it was observed that leaf transported in the humidified trailer was preferred to leaf transported in normal trailer. The comparative valuations are shown in Table 1.

Table 1. Mean values derived from the comparative valuations given by Tocklai and Calcutta Panels of Tasters

Grades	Normal trailer Rs/kg	Humidified trailer Rs/kg
BP	5.55	5.62
PF	5.55	5.80
DUST	5.52	5.56

Under commercial conditions the difference in value is likely to be higher, as high as 0.50 paise per kilogram.

Effect of 8 groove and 10 groove C.T.C. segments: The use of 10 groove segments in C.T.C. rollers instead of 8 groove was suggested in the Ann. Rep. for 1969-70, p. 65. More experiments were carried out in 1970 and the results showed that it would be of advantage to use 8 groove segments for the first cut followed by 10 groove segments in the second or third cuts. This applied for both RV/ C.T.C. and Roll/C.T.C. types of manufacture.

It was confirmed that the angle of the milling cutter for sharpening the 10 groove segments should be set at 70°.

Table 2 shows the percentages normally obtained from the experiment carried out by using 8 and 10 groove C.T.C. segments with first and second cuts in the C.T.C. machine.

Table 2. Grade percentages normally obtained by using 8 groove and 10 groove C.T.C. segments with different cuts

Grades	2 cuts 8 groove	2 cuts 10 groove	1 cut 8 groove 1 cut 10 groove
	Grade percentage	Grade percentage	Grade percentage
BP	35.0%	29.81%	35.04%
PF	54.0%	57.06%	53.61%
DUST	8.12%	12.06%	10.85%
RESIDUE	2.88%	1.07%	0.50%

Illumination trial : Teas were made from bushes illuminated by artificial light and treated with gibberellic acid. These teas were manufactured in the miniature factory and tasted by the Tocklai Taster but no definite conclusion had been arrived at from the assessment. It is proposed to continue the trial in 1971-72.

Dual manufacture with some of the Tocklai TV clones : Encouraging results were obtained from a preliminary experiment designed to find out the suitability of TV clones for different methods of manufacture. It is proposed to continue the experiment in 1971-72.

Effect of Field Practices on the Cup Characters of Made Tea

Agriculture Department

B. 112.1 Fineness of plucking : The results reported in the Ann. Rep. for 1969-70, p. 65 are confirmed. Quality and value of teas decreased with the length of the plucking round.

Field Advisory Department

AS44 — N. P. K. Manuring of Young Tea : Application of N. P. K., each at the rate of 112 kg per hectare, had no adverse effect on the cup characters of made tea.

Botany Department

Selection of Mother Bushes : 110 samples, each of sixty grams, were manufactured in the miniature factory by the C.T.C. method for the selection of mother bushes and 42 bushes were selected for rooting trial during the year.

Grafting Experiment : 19 miniature samples were manufactured in the miniature factory by the C. T. C. method. The tasting results of this experiment showed that the root stock can have some influence on the quality and valuation of the leaf from the grafted scion.

Parent-progeny Relationship : 25 miniature samples were manufactured in the miniature factory by the C.T.C. method. In general, progeny quality was found to be related to parental quality.

Biclonal Progeny : Seven samples of 1 kg each, were manufactured by the C.T.C. method. This year's tasting showed progeny of the cross Hathipurbat — CA to possess the best liquor quality, followed by Sagong D.M. and Nilkanta PF.

Clonal Proving Station, Darjeeling : 17 clones together with 4 controls were manufactured at the miniature factory of the Station and sent for evaluation by the Tocklai Taster during 1970. 3 clones i.e. Bannockburn 157, Phoobsering 312, Tukdah 145 were tentatively selected on the basis of quality for the Darjeeling tea districts.

Pesticide testing Unit

Tainting Trial : 22 samples were manufactured and tasted by the Tocklai Taster to ascertain whether the untested chemicals imparted any taint. Samples treated with Phosvel imparted taint to the made tea. There was a suspicion of taint also in the samples treated with Difolatan.

Residues : 40 samples were manufactured for residue testing.

Manufacturing Advisory Department

Survey : A survey was undertaken to find out the quantity of tea made by different methods for the season 1970 in N.E. India (excluding Darjeeling). Figures I, II, III and IV show the trend.

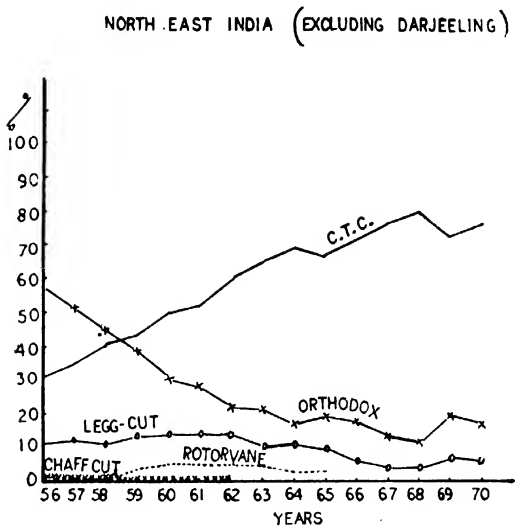


Fig 1. Trend shows the total quantity of tea produced in North-east India (excluding Darjeeling) by different methods of manufacture

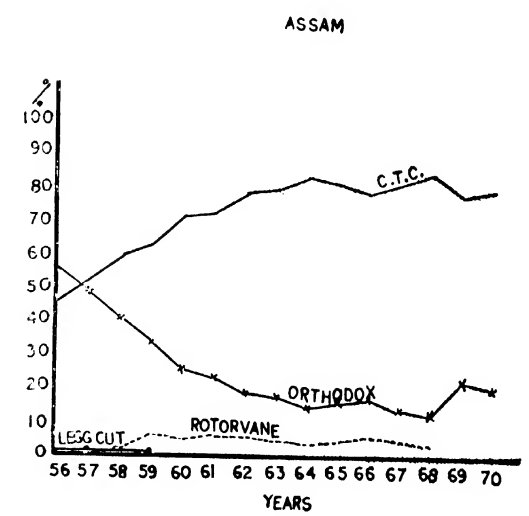


Fig 2. Trend shows the total quantity of tea produced in Assam by different methods of manufacture

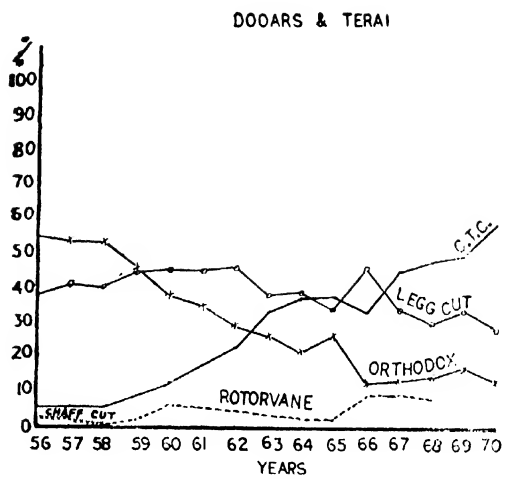


Fig 3. Trend shows the total quantity of tea produced in Dooars & Terai by different methods of manufacture

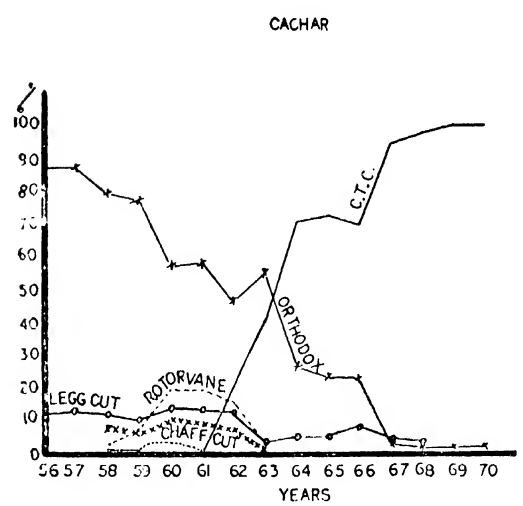


Fig 4. Trend shows the total quantity of tea produced in Cachar by different methods of manufacture

From the trend it is observed that in 1970 N.E. India (excluding Darjeeling) produced 2.35% less of orthodox teas compared to 1969 while 3.07% more of C.T.C. teas was produced. Legg-cut production went down by 0.62% in 1970 compared to 1969.

In Assam Valley production of orthodox tea went down by 1.77 while in the Dooars and Terai it went down by 3.94%. Estates are finding it worthwhile to confine the orthodox manufacture mainly to the second flush period when there is quality in the leaf. This possibly is an indication that orthodox tea by name is unlikely to fetch remmunerative prices.

Amount of tea taken into survey :
1969 - 166,843,662 kg
1970 - 177,356,447 kg

TESTING OF COMMERCIAL PRODUCTS

Cleaning Agents : 'Esskay's Multipurpose cleaner, supplied by Messrs National Distributors, Calcutta, was found unsuitable for cleaning green leaf processing machines and fermenting surfaces.

Kortolat A-500 : A sample of chemical received from Messrs Williamson Magor & Co. Ltd., was tested to find out its suitability in curing water containing excessive iron. The preliminary tests indicated that this chemical would be of help in curing water containing excessive iron for use in tea factories.

Corrugated Hardboard : Experiments were carried out with corrugated board tea chest with fixed aluminium foil paper linings and corrugated fibreboard boxes (containers) supplied by Cardboard Printing and Processing Industries Ltd., Calcutta and Cardboard Box Mfg. Co., Calcutta, respectively.

Tea packed in cardboard boxes lined with aluminium lining seemed to keep better compared to the teas packed in standard plywood tea chest lined with aluminium linings. However, the cardboard boxes received so far have been extremely weak, and unless the boxes are made stronger, the cardboard boxes will not be of much use for packing of tea.

TEA TASTING AND VISITS

Tea tasting : During the season 3,395 experimental samples from Tocklai, 11,991 samples from estates for advising on manufacture and 3,023 clonal samples from estates were tasted and evaluated.

Touring : The Manufacturing Adviser & Tea Taster made 105 factory visits for advising on manufacture. He also attended 14 group tastings during the season. The Second Tea Taster accompanied the Manufacturing Adviser & Tea Taster in a number of estate visits.

Lectures : Two lecture courses on Manufacture together with demonstrations were conducted by the Manufacturing Adviser & Tea Taster in co-operation with the Engineering Development Department. Lectures on manufacture were given by the Manufacturing Adviser & Tea Taster and the Senior Research Engineer at Deohal Tea Estate at the request of the General Manager of Warren Tea Group.

Meetings : The Manufacturing Adviser & Tea Taster attended four Area Scientific Committee Meetings.

Engineering Development Department

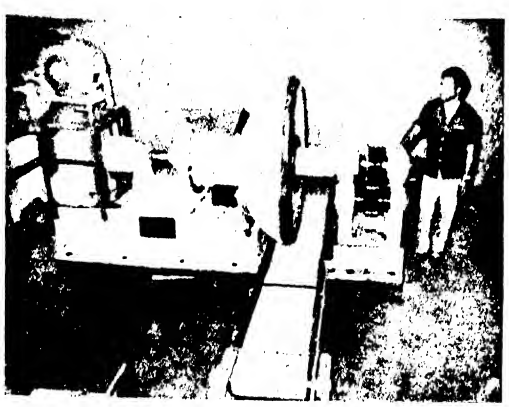
RESEARCH AND EXPERIMENT

ROLLING

Continuous Green Leaf Processing Machines

1. Disc Type Continuous Roller : Experiments with the prototype 81 cm (32″) Disc Roller with a 20.4 cm (8″) diameter feed barrel was continued throughout the season.

Early observations showed that for better twisting action and better leaf style an even distribution of leaf in the gap between the two discs and a well regulated supply of leaf around the periphery of the discs are of vital importance. To achieve this, a stationary distributor plate, distributing leaf into the processing zone was devised. Fitment of this device considerably improved the style and the liquors of the teas and the Tocklai Tea Taster reported in favour of the fitment.



Disc Roller
(Commercial Version)

A similar fitment was also tried out in the prototype 122 cm (48″) Disc Roller at Nahorani T. E. The general trend of results obtained showed that while the distributor plate definitely improved the liquoring characteristics, the colour of the tips still remained pale. This can be attributed to the short length of the processing time (one minute) which does not provide adequate opportunity to the tips to be soaked with juice, exuded by the leaf being processed.

Other experiments carried out with different fitments gave only limited success.

A set of comparable sorted grades from Tocklai's 3 roll orthodox manufacture and those made after 3 passes through the 81 cm (32″) prototype disc roller were sent to the London Panel of Tea Tasters. The London Panel's general remarks are:-

"No valuation have been placed on these teas but if both sets were marketted, we feel that A set (i.e. three passes through the disc roller) would realise 3 d. overall".

The 122 cm (48″) prototype machine at Nahorani T. E. operated satisfactorily till the beginning of October when the 12″ sheet aluminium feed barrel gave away. Summing up the results from this machine the Estate Manager wrote :

"The Disc Roller only gave good rolling when the leaf was hard withered, of good standard (i.e. 60% plus good leaf) and had been rolled once and preferably twice in a normal roller."

"The best results were obtained by using the Disc Roller for third roll following two rolls by conventional crank rollers."

The following is a typical set of figures obtained when the Disc Roller is used in conjunction with a Crank 36″ Roller. Comparative figures for normal manufacture are also given :

Disc	**Normal**
1st roll	1st roll
36″roller 20% fine	48″ roller 20% fine
2nd roll	2nd roll
Disc Roller 15% fine	36″ roller 25% fine
3rd roll	3rd roll
Disc Roller 14% fine	36″ roller 19% fine
51% Coarse	36% Coarse

From the trend of results, it appears that the machine will be ideally suited for all tea growing areas where broken orthodox grades are sold at a premium e.g. South India and Ceylon. Further work on the machine, with cast and machined components as against the present lighter, partially

machined fabricated components will be carried out next season to explore its capabilities further. The commercial prototype of the Disc Roller made by the Association's Licensees, Port Engineering Works Ltd. has already been received at Tocklai.

Mini Disc Roller : The commercial version of the Mini Disc Roller as approved by the Tocklai Engineering Department was made by Port Engineering Works. This roller is specially adapted to miniature manufacture for clonal selection work and is suitable for 50 to 100 g leaf samples equally well. The roller was tried at Tocklai against the Prototype version. Table 1 gives the valuations of comparative samples from the two machines:

Table 1. Comparative valuation of Tocklai made Prototype Mini Disc and Commercial Mini Disc

Date of test	Prototype Mini Disc 2 passes	Commercial Mini Disc 2 passes
22.10.70	3.90	5.00
24.10.70	5.00	4.50
27.10.70	5.10	5.00
29.10.70	5.00	6.00
29.10.70	5.50	5.10
3.11.70	5.00	5.40
7.11.70	3.90	3.00
10.11.70	5.00	5.40
Average valuation	4.80	4.92

2. Continuous Tea Roller : Vertical Type : There is no further development on this machine.

3. Barbora Leaf Conditioner : Three 15" diameter commercial units of this machine were manufactured by Port Engineering Works and installed at Powai T. E. in Upper Assam during June. Initial trials have shown that the adjustments provided for variation of the type and toughness of leaf at different parts of the season were not sufficient to cope with the variation of wither, banjiness and hardness which can be expected in a commercial factory towards the end of the season. To improve the machines, experiments were carried out at Tocklai and in line with the results, one machine was modified by incorporating the following :

(a) Segmentation and staggering of the helical battens on the cone to eliminate escape routes for under processed leaf.

(b) Re-alignment and re-shaping of the studs fitted to the inside wall of the sleeve to eliminate stagnation of leaf on the wall and averting exposure of fibre.

(c) Fitment of one pin at a distance of half a pitch away from the thrust face on the discharge end of the feed worm on the inside wall of the barrel nearest to the feed conveyor and cutting a notch on the feed worm to allow for its rotation with the pin fixed in position.

(d) Fitment of a Iris type of end plate to the discharge end of the cone to make instant adjustment of the processing action of the BLC possible. This has been considered to be necessary to cope with different degrees of wither, and different types of leaf, a factory has to cope with in the course of a day's manufacture.

Results of the trial of this modified BLC against one of the unmodified one with really hard leaf towards the end of the season are given in Table 2.

Table 2. Comparative efficiency of Unmodified and Modified Barbora Continuous Leaf Conditioner

	Unmodified BLC	Modified BLC
Rate of processing at 38 rpm.	780 kg withered leaf/hr	1080 kg withered leaf/hr
Percentage of processed leaf	51.3%	67.6%
Percentage of under processed leaf	48.7%	32.4%

After the success of this modified BLC, the other two BLCs were also modified in the same way at Tocklai and returned to Powai. A modified BLC was tried at Tocklai against a 6" Rotorvane which is normally found to process leaf to a better degree in Tocklai comparative tests. Results of the trial are given below :

Date of manufacture 25.3.71

Sample A - - 15" BLC one pass + 2 cuts C.T.C
Sample B - - 6" Rv. one pass + 2 cuts C.T.C.

Taster's Report

Leaf : Samples A Blacker, less dusty compared to Samples B.

Infused Leaf : Fair little to choose.

Liquors : Set A samples are distinctly much brighter and brisker than set B samples and are distinctly preferred.

Biochemist's Report	TF%	TR%
15" BLC one pass + CTC 2 cuts	1.08	13.13
6" Rv. one pass + C.T.C	1.08	13.34

There is no difference between 15" BLC and 6" Rv. manufactured samples.

Leaf Sizer Attachment to the Barbora Leaf Conditioner : During the year experiments were carried out with a Leaf Sizer Attachment to the 8" Prototype BLC at Tocklai with a view to develop the conditioner to a "complete tea processing machine". Various permutations and combinations were tried against standard roll/ C.T.C. with different pattern of cutter blades fitted to the discharge end of the cone and its extension. A summary of the results of trials is given in the Table below :-

Table 3. Comparative valuations of teas manufactured by Standard Roll/C.T.C method and the Prototype Barbora Leaf Conditioner with leaf sizer attachment

Method of manufacture	No. of cuts or passes	No. of tests	Average valuation in Rupees	Remarks
8" BLC/Single plate leaf sizer	1 pass		11.75	BLC/Leaf sizer teas are commented on very favourably by the Tocklai Taster
do	2 passes	2	8.50	
do	3 passes		13.25	
Standard Roll/C.T.C	2 cuts		6.50	
8" BLC/Single plate leaf sizer	2 passes		5.80	
-do-	3 passes	1	5.00	
Standard Roll/ C. T. C.	2 cuts		6.00	
8" BLC/Single plate leaf sizer	1 pass		6.52	
-do-	2 passes	1	6.00	
Standard Roll/C. T. C.	2 cuts		6.37	
8" BLC/Single curved plate sizer	1 pass		6.25	
-do-	2 passes	2	6.50	
Standard Roll/ C. T. C.	2 cuts		6.25	
8" BLC/Double plate leaf sizer	1 pass		6.59	
do-	2 passes	8	6.21	
Standard Roll/C.T.C	2 cuts		6.39	

Teas processed through the Leaf Conditioner with the leaf sizer attachment were also sent for biochemical analysis. The findings together with Tea Taster's valuations are given in Table 4.

Table 4. Comparative Biochemical Evaluation of teas manufactured by Standard Roll / C.T.C. method and Barbora Continuou Leaf Conditioners with leaf sizer attachment

Date	Method of manufacture	No. of cuts or passes	TF%	TR%	Biochemist's remarks	Tocklai Taster's valuation in Rs.
30.6.70	8" BLC/Single plate leaf sizer	1 pass	1.01	12.64	Under fermented	9.50
	-do	2 passes	1.04	12.42	-do-	7.00
	-do	3 ,,	1.03	13.70	-do-	6.50
	Standard Roll/CTC	2 cuts	1.01	16.02	Well fermented	6.00
7.7.70	8" BLC/Single plate Leaf sizer	2 passes	1.01	13.60	Under fermented	5.80
	-do	3 ,,	0.92	13.98	-do-	5.00
	Standard Roll/ CTC	2 cuts	1.12	15.28	Well fermented	6.00
9.7.70	8" BLC/Single plate leaf sizer	1 pass	0.82	13.70	Under fermented	5.70
	-do-	2 passes	0.69	13.70	-do	5.00
	Standard Roll/CTC	2 cuts	1.05	16.34	Well fermented	5.80
14.7.70	8" BLC/Single plate leaf sizer	1 pass	1.35	13.26	Under fermented	8.00
	do -	2 passes	1.35	13.84	do -	8.00
	8" BLC/Single curved plate sizer	1 pass	1.29	13.48	-do-	6.00
	do -	2 passes	1.31	13.55	-do-	6.00
	8" BLC/Double plate leaf sizer	2 passes	1.27	14.23	Well fermented	5.00
	Standard Roll/CTC	2 cuts	1.39	15.68	-do-	6.50

Arrangements were being made at Tocklai to fabricate one Leaf Sizer Attachment for use with a commercial 38 cm (15") Leaf Conditioner and/or with a 38 cm (15") Rotorvane. The unit after fabrication will be tried under commercial working conditions.

4. Tocklai Continuous Roller : Apart from the fact that the 15" Prototype T.C.R. at Nagri T.E. Darjeeling has been brought back to Tocklai, there is nothing to report on the machine.

5. Rotorvane : Following the success in improving the throughput of the BLC at Powai T.E., experiments were conducted with the prototype 15.2 cm (6") Rotorvane at Tocklai, which was fitted

with a pin near the feed conveyor side of the barrel, half a pitch away from the thrust end of the worm and cutting a notch on the feed worm to allow its rotation with the pin in position.

The trial has indicated that this fitment prevented jamming and improved the rate of feed by as much as 38% with this 15.2 cm machine running at 48 rpm. Estates suffering from the Rotorvane's proneness to jamming, will do well to incorpotate this fitment to their equipment. Some of the commercial estates have already been provided with the necessary drawings. Results from the few trials in the commercial factories are satisfactory.

FERMENTATION

Tocklai Continuous Fermenting Machine : Although the Tocklai Continuous Fermenting Machine proved its worth in our trials at Sycotta T.E. last year its commercial manufacture has been deferred for further trials with different kinds of airflow patterns to see if more even temperature distribution can be effected economically. The chamber of the machine was, therefore, divided into four sections in place of previous two, and a new set of air ducts was incorporated for greater flexibility in direction of air flow in different sections. The machine with these modifications was put into commission from the 17th April 1970. For the first two weeks upto the 29th April leaf from orthodox type of manufacture was fermented through the machine. From the 5th May upto the end of the season, C.T.C. processed leaf from Roll/Rotorvane/C.T.C. or Rotorvane/C.T.C. method of manufacture was fermented in the machine. A summary of the results given in Table 5.

Table 5. Effect of air-flow pattern inside the 5' Prototype Continuous Fermenting Machine at Sycotta Experiment

Method of manufacture	Air flow pattern feed to discharge				No. of samples collected	No. of samples from C. F. M. preferred by Tocklai Taster
Orthodox	U	D	U	D	6	2
	D	U	D	U	3	1
Roll/Rv/CTC	U	D	U	D	24	7
	D	U	D	U	6	2
	U	U	D	D	17	12
	D	D	U	U	7	4
	D	D	D	U	16	13
Rv/CTC	U	D	U	D	259	134
	D	U	D	U	26	12
	U	U	D	D	28	14
	D	D	U	U	16	9
	D	D	D	D	2	2
	U	U	U	U	2	0

U = Suction — Upwards
D = Delivery — Downwards

A few samples were also drawn from different layers of fermented leaf from the same leaf bed with different air flow patterns. The taster's valuations of these teas are given in the table 6.

Table 6 Effects of air-flow pattern on the valuation of teas at different levels inside the bed of leaf in the 5' prototype Continuous Fermenting Machine

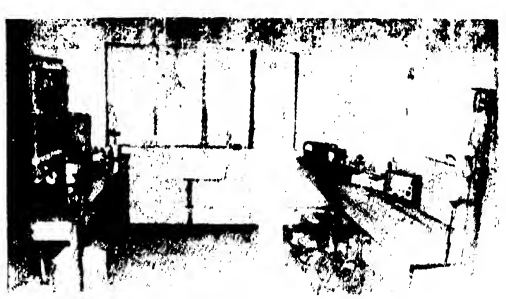
Trial No.	Position of leaf in the bed	Flow pattern			
		Up Down	Up Down	Up Up	Down Down
1	Top layer	Rs. 5.40	Average	Rs. 5.60	Average
	Middle layer	Rs. 6.00	Rs. 5.30	Rs. 5.10	Rs. 5.23
	Bottom layer	Rs. 4.50		Rs. 5.00	
2	Top layer	Rs. 6.20	Average	Rs. 6.30	Average
	Middle layer	Rs. 5.00	Rs. 5.40	Rs. 6.00	Rs. 6.27
	Bottom layer	Rs. 5.00		Rs. 6.00	
3	Top layer	Rs. 5.70	Average	Rs. 5.60	Average
	Middle layer	Rs. 4.00	Rs. 4.73	Rs. 8.00	Rs. 6.80
	Bottom layer	Rs. 4.50		Rs. 6.00	

From these results it can be seen that different combinations of air flows within the fermenting chamber did not lead to any striking difference among the final products. Hence it was decided that the best course for the recirculatory air-stream, was to follow a simple path in the chamber by making the air flow upwards in one half of the chamber and downwards in the other half. A reversing switch should be incorporated in the machine to alter the directions of air flow in the two halves of the chamber. This will enable the user to vary the air-flow in accordance with the prevailing manufacturing conditions during the day and within the season.

Meanwhile tenders were invited for its commercial manufacture and it is hoped that a decision as to its commercialisation would be made early.

MOISTURE IN TEA

Trials made with the moisture meter built in the laboratory showed that the meter is not fully capable of taking the weight of the sample into account. As such, a general calibration to hold good with any grade of tea was not possible. Studies were made for further alterations and modifications



A View of the Research Engineering Laboratory

in the circuit and the probe. Meanwhile, work on collection of data on moisture content of green leaf and made tea is continued using different types of moisture meters and checking them up against standard oven method of determining moisture. A "Protimeter" grain moisture tester donated to

Tocklai through the Senior Research Engineer by the manufacturers is being calibrated to measure moisture content of partially dried tea to explore the possibility of its use at some intermediate point in the drier to control the process of tea drying.

Miscellaneous

Mr. Hadfield has observed during his work at Cambridge that withering under well-lit conditions cuts down the loss of solid matter by half. To follow up on this experiment the Engineering Research and Development Department at Tocklai conducted a set of experiments by exposing tea shoots to light during the period of withering. These teas were manufactured for comparison with those withered normally. Both these teas were manufactured under identical conditions. The tables 7 and 8 show the Tocklai Tea Taster's and the Biochemister's assessments :—

Table 7. Tocklai Taster's Valuations

Date of manufacture	Valuations of unsorted samples Rs/kg				Preference
	A Normal Wither		B Leaf exposed to light during withering		
	Fines	Coarse	Fines	Coarse	
13.10.70	5.60	5.00	5.60	5.00	B
17.10.70	6.00	5.60	7.00	6.30	B
20.10.70	5.60	4.60	5.10	5.00	- -
22.10.70	5.00	4.50	4.50	4.00	A
24.10.70	3.50	3.00	4.00	3.50	B
27.10.70	4.50	4.65	5.00	4.50	B
3.11.70	5.00	4.60	5.80	5.20	B
7.11.70	5.00	3.90	5.80	5.00	B
10.11.70	7.00	5.40	5.80	3.90	A
12.11.70	5.80	4.90	5.00	4.90	A
17.11.70	5.10	4.90	5.80	5.00	B

Table 8. Biochemist's assessment

Date of manufacture	Type of sample	A Normally withered		B Leaf exposed to light during withering		Preference
		TF	TR	TF	TR	
13.10.70	Fines	0.88	10.67	1.03	12.37	B
	Coarse	0.68	8.87	0.70	8.72	Similar
17.10.70	Fines	0.88	12.13	0.79	13.30	A
	Coarse	0.58	9.23	0.59	9.42	Similar
20.10.70	Fines	1.03	13.69	1.07	13.38	Similar
	Coarse	0.79	10.65	0.74	10.06	Similar
22.10.70	Fines	0.90	11.86	0.90	12.42	Similar
	Coarse	0.65	9.04	0.65	9.25	Similar
24.10.70	Fines	1.44	13.62	1.42	13.34	Similar
3.11.70	Fines	0.90	10.09	0.90	10.09	Similar
	Coarse	0.52	6.92	0.52	7.20	Similar
10.11.70	Fines	0.99	12.00	0.97	11.22	A
	Coarse	0.63	8.33	0.63	8.75	Similar

Although in most cases the Biochemist found the samples similar, the Tea Taster has preferred the teas manufactured from leaf exposed to the action of light during withering. Further work on these aspect is therefore called for.

General

The Senior Research Engineer attended two meetings of the Engineering Sub-Committee in Calcutta, the Joint Meeting of the Area Scientific Committees at Tingri and Doom Dooma and two meetings of Area Scientific Committees of Cachar and South Bank East and West. He paid three visits to Calcutta to discuss the problems encountered in getting the best results from the Tocklai machinery now being handed out to licensees for commercialisation. Apart from his routine visits to Sycotta, Hunwal and Powai factories, the Senior Research Engineer paid 39 advisory visits to different factories. He also attended the demonstration of the Sharples "Vibroscreen" Tea Sorter, held at Duklingia. He advised the manufacturers of this machine in India, Messrs. Pennwalt, regarding the points which must be attended to by them, to make it an ideal sorter for North East Indian C.T.C. teas. The Senior Research Engineer was on long leave from the 2nd January till the 28th February 1971.

Both the Senior and Second Research Engineers lectured in the first and second courses of Factory Management held at Tocklai. The Second Research Engineer attended four meetings of the Area Scientific Committees at Tingri, Dibrugarh and North Bank East and West. He also visited five factories apart from his routine visit to Sycotta Factory.

Sri Kanak Chandra Barua, Junior Scientific Assistant of the Department resigned in the month of June and his place was filled by Sri Pradeep Kumar Dutta.

Statistics Department

Help to Other Departments

The Department continued to extend co-operation and help in solving a large number of statistical problems encountered by research workers of practically all the Departments of the Station. Analyses of a number of long-term experiments on the electronic computer at the Indian Institute of Technology, Kanpur continued throughout the

SOEMTRON 220/3 an electronic desk calculator being used for efficient and faster compilation

year. For the purpose of these analyses, a number of FORTRAN programmes had to be written. One of the two programmes which were prepared earlier to analyse the data of the C 5 project, was further improved to increase the efficiency of computations on the electronic computer.

Statistical Study of the Chemistry of Tea

The influence of biochemical constituents and their effects on briskness, quality and cash valuations, both of C. T. C. and orthodox teas, were discussed in the Annual Report for 1969-70, pp. 77-79. The influence of biochemical constituents and their effects on colour, brightness and strength were investigated during the year. The computations of the large mass of data were carried out on an IBM 7044 electronic computer at the Indian Institute of Technology, Kanpur. The computer analyses decoded so far have led to the following tentative findings.

The 18 and 19 biochemical constitutents of C.T.C. and orthodox teas respectively taken for this study, were the same as those used for the study of briskness, quality and cash valuations. These constituents were considered together in the analysis to find out their relative contributions to, and their types of relationship with the colour, brightness and strength, both of C. T. C. and orthodox teas. Analyses were carried out separately for each taster and for each method of manufacture.

In general, the biochemical constituents which were significant for individual tasters, together contributed 71 p.c. to 87 p. c. towards colour, brightness and strength of C.T.C. teas. Amongst these significant constituents, seven were found to be common for colour to more than two tasters and also two tasters showing similar effect of the constituents. Similarly six constituents were common for brightness and nine for strength.

For orthodox teas, amongst the significant biochemical constituents for individual tasters which together contributed, in general, 74 p.c. to 89 p.c. towards colour, brightness and strength, eight for colour, five for brightness and seven for strength were found to be common to more than two tasters and also two tasters showing similar effect of the constituents.

By comparing the results of C.T.C. and orthodox teas it was noticed that five biochemical constituents, namely, total oxygen uptake of unprocessed tea shoots, and TF, TR, EGCG and TG of black tea, were found to affect the colour, both of C.T.C. and orthodox teas. Similarly three biochemical constituents, TF, TR and ECG of black tea, were found to affect the brightness, and four constituents, total oxygen uptake and ECG of unprocessed tea shoots and moisture and TF of black tea, were found to affect the strength, both of C.T.C. and orthodox teas.

Detailed analyses are being continued.

Sampling and Experimental Technique

The study to maximise the efficiency and minimise the cost of experimentation on the adjustment of post-treatment yields by the ancillary variables,

namely, pretreatment yields upto June, July & August, September, October, September to end season, October to end season, November to end season, whole season's crop and the pretreatment pruning weights, was continued during the year. Analysis of data from 23 long-term experiments ranging from 5 to 18 years in the Assam valley, Cachar, Dooars and Darjeeling showed that amongst the ancillary variables, pretreatment yields from September to end season was most efficient in the plains of North East India for the adjustment of post-treatment yields. In Darjeeling, however, pretreatment yields of July & August was found to be the most efficient.

Further, in general, the adjustment of post-treatment yields by the respective efficient pretreatment yields was found to be effective on the yield data of the first year, and the cumulative yields of all subsequent years of experimentation under reference.

These results, therefore, suggest that instead of taking the whole season's crop as the ancillary variable, pretreatment yields from September to the end of the season in the plains of North East India and July & August yields in Darjeeling, will be sufficient to adjust the post-treatment yields.

Long-term Survey-Experiments on Defoliation

During 1969/70 cold weather the two main plot treatments, Prune-Deep Skiff and Prune-Deep Skiff-Medium Skiff, were deep skiffed and light pruned, respectively. The data collected during the year from the experiments in the Dooars were analysed.

The red spider infestation was generally found to be low in all the control (no defoliation and no chemical spraying) plots, and in all the treated plots it was controlled satisfactorily. Since red spider infestation was low, and defoliation or prophylactic spraying of chemical controlled red spider satisfactorily, practically no spraying was necessary in the chemical palliative plots. The yield of defoliated plots was, however, found to be significantly lower than the undefoliated plots with or without chemical prophylactic spraying with Tedion. The loss was found to be 13 p.c. over the undefoliated, chemical prophylactic sprayed plots. As in previous years (Ann. Rep., 1968-69, pp. 102-106 and 1969-70, p. 80), this loss may be attributed to the detrimental effect of the continuous defoliation. Further, there was no significant difference in yield between the chemical prophylactic sprayed plots and the control (no defoliation and no chemical spraying) plots.

The yield of the two-year cycle plots, which were deep skiffed during the 1969-70 cold weather, was significantly higher than the three-year cycle plots which were light pruned.

The experiment will be continued to study the objectives outlined in the earlier report (Ann. Rep., 1968-69, pp. 102-106).

Touring and Advisory

The Statistician visited the Indian Institute of Technology, Kanpur, once and two members visited thrice in connection with the statistical analyses of data from long-term and complex experiments on the IBM 7044 electronic computer. The Statistician also visited the Indian Statistical Institute and Blue Star Limited, Calcutta, during the year. He attended the Area Scientific Committee meetings in the Dooars, Terai and Darjeeling. Three members of the Department visited Bokahola T. E. weekly in connection with the uniformity trial there. Messrs R. N. Deb and P. K. Karmoker, Scientific Assistants, attended a course on programming and applications of electronic computer at the Indian Statistical Institute, Calcutta, from 26.10.70. to 23.1.71.

Library and Publication Department

LIBRARY

General

The Library added three more Scientific journals to the subscription list and a total of 126 journals were subscribed during the year. The subscription rates to the foreign scientific journals again increased during the year.

Reorganisation

Due to shortage of space in the library, most of the text books frequently referred to by individual Departments, were transferred to the Departments concerned and the books which were used by more than one Department and those of reference type, were retained in the main library.

Ten new steel racks were purchased to keep the books and journals in a classified order, but for want of floor space the work could not be completed during the year.

Some duplicate old journals were sold to a Delhi firm to make room for new journals. The surplus Tocklai publications which were more than three years old, were also similarly disposed of.

Floor space, however, continues to be a problem in the library. It is, of course expected to be solved during 1971-72, when the Director's office would be shifted to the new Directorate Building.

Loan Service

29 post-graduate students of Assam Agricultural University, one Lecturer each from D. C. B. Girls' College, Jorhat, J. B. College, Jorhat, Dibrugarh University and the Assam Agricultural University, used the Tocklai library. Furthermore, the entire batch of students of Tea Science of Assam Agricultural University; eight Tocklai trainees and the trainees of the V. P. Course, at Borbhetta attended the library during the year. The Tocklai Scientific Staff used the library as usual.

A total 560 publications were issued to the Departments and 1172 publications were consulted in the library.

Book Binding

A total of 453 volumes of journal were bound this year and rebinding of the old volumes will be done next year.

Library Statistics

Books added during the year	—	116
Periodicals & Journals	—	1509
Pamphlets	—	612
Photocopies	—	7
Microcopies	—	7
Reprints	—	3
Maps	—	3
Publications consulted	—	1172

PUBLICATIONS

The Publication Section was kept specially busy this year due to the publication of large number of T. E. Serials (revised and new), Soil Survey Reports, Advisory leaflets, Miscellaneous cyclostyled reports etc. in addition to the usual publications.

Publication Section is busy throughout the year in despatching Tocklai publications

Due to an increase in the number of subscribers of our publications, the correspondence relating to publications, increased considerably.

As it has been decided to publish the newsletter "Two & A Bud" half-yearly in June and December

from 1971, the March 1971 issue of the Two & A Bud was not published. In lieu of the March issue, however, two Advisory leaflets were published.

The following publications were issued during the year.

(1) **Two & A Bud**

Vol. 17, Nos. 1 and 2 (combined issue), 3 and 4.

(2) **Tocklai Occasional Scientific Papers**

Soil Survey 1967/68 No. 8, Results for Lakhimpur and Bishwanath districts.

Soil Survey 1967/68 No. 9, Results for Borsola and Mangoldoi districts.

(3) **Advisory leaflets**

No. 1. Guide lines for the manufacture in Cachar of exportable tea during the second flush period by R. Choudhury.

No. 2. Some notes on Pests, Diseases and spray chemicals by T. D. Mukerjea and M. C. Katoni.

(4) **Miscellaneous reports**

Annual Scientific Report for 1969/70.

Proceedings of the twentyfourth Conference held at Tocklai on 11th, 12th & 13th, November, 1969. (Circulation restricted)

Report on a visit to the United Kingdom and Kenya by D. N. Barbora (Circulation restricted).

Report on a visit to the United Kingdom by S. K. Dutta (Circulation restricted).

Report on a visit to South India by R. Choudhury (Circulation restricted).

Engineering Development Department Quarterly Reports for quarter ending from March to December, 1970 (Circulation restricted).

(5) **Tea Encyclopaedia Serials (revised)**

Serial No. 72/2—Advise to tea estates on soil samples and method of soil samplaing.
Serial No. 39/1—Canker of shade Trees.
Serial No. 71/3 – Red Spider.
Serial No. 16/2—Cleaning tea machinery and fermenting floors.
Serial No. 91/1—Key for Identification of the commoner Diseases of tea.
Serial No. 60/2—Skilling of tea in growing seasons
Serial No. 84/1—Green leaf shifting.
Serial No. 36/4—Hail damage on tea estates.
Serial No. 83/1—Factory requirements for a 3,730 quintals (10,000 Maund) factory in the plains.
Serial No. 32/1—Rat poisons (Amendment slip).
Serial No. 76/1—Control of Looper Caterpillar. (Amendment Slip).
Serial No. 78/2—Cricket Control - (Amendment Slip).
Serial No. 113/1—Scale insects and Mealy bugs on tea bushes & tea roots— (Amendment Slip).
Serial No. 106—*Helopeltis theivora* Waterh (Tea Helopeltis).
Serial No. 104/1—Pink & Purple Mites, Scarlet Mite (Amendment Slip).

Tea Encyclopaedia Serials (New)

Serial No. 176 - The manuring of Mature Tea.
Serial No. 178 - Rehabilitation & Mulching Crops.
Serial No. 179 - Shade and Shade Trees (Part I - IV)
Serial No. 180 - Branch Canker, Sunscorch, Die-Back and thorny Stem Blight.
Serial No. 182 - Scanvenging and Mound Building Termites.
Serial No. 190 - Flooding and Treatment after flooding.
Serial No. 191—Determination of moisture Content of tea leaf at various stages of manufacture by using Kaybee Infra-Red moisture meter, type X-14 (AGAT).

Appendix - A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
By
THE ADVISORY DEPARTMENT
South Bank, Assam

Project	Site	Index	Year of starting
Rehabilitation of land	Duklingia	AS 48	1964
	Ghillidary	AS 49	1964
	Hansara	AS 50	1964
N. P. K. Manuring	Murmuria	AS 11	1956
	Sycotta	AS 34	1960
	Katonibari	AS 44	1963
	Hunwal	AS 51	1964
	Dirok	AS 63	1965
	Ghillidary	AS 88	1968
	Hunwal	AS 92	1969
	Doom Dooma Tea Co.	AS 95 A	1969
	,, ,,	AS 95 B	1969
	Haroocharai	AS 98	1970
Nitrogenous fertilizer	Sycotta	AS 56	1964
	Sagmootea	AS 62	1965
	Joonktolee	AS 64	1966
	Nahorhabi	AS 65	1966
	Furkating	AS 69	1966
	Halmirah	AS 71	1966
	Cinnamara	AS 77*	1966
	Meleng	AS 78*	1966
	Borsillah	AS 79*	1966
	Joonktolee	AS 82	1967
	Gabroo Purbut	AS 83	1967
	Haroocharai	AS 99	1970
Pruning	Dufflating	AS 84	1957
	Nahorhabi	AS 90	1968
	Margherita	AS 97	1969
Cultivation and Weed Control	Cinnamara	Short	1965
	Dessoie	term	1969
	Hunwal	trials	1970
Irrigation	Borahi	AS 67	1966
	Gorunga	AS 68	1966
	Gabroo Purbut	AS 70	1966
	Dejoo Valley	AS 73	1966
Jat and Clonal Trial	Tyroon	AS 89	1968
	Tyroon	AS 96	1969

*Effect of nitrogen with and without liming

NORTH BANK, ASSAM

Project	Site	Index	Year of starting
Rehabilitation of land	Tarajuli	AN 46	1964
	Deckiajuli	AN 47	1964
N. P. K. Manuring	Borjuli	AN 85	1968
	Dekorai	AN 87	1968
	Ananda	AN 93	1969
Nitrogenous fertilizer	Nahorani	AN 59	1964
	Gingia	AN 80*	1966
	Hatigar	AN 91	1969
	Ananda	AN 94	1969
Pruning	Phulbari	AN 58	1964
	Kolony	AN 76	1966
Irrigation	Balipara	AN 55	1963
	Sessa	AN 61	1965
	Durrung	AN 74	1966
	Mazbat	AN 75	1966
Cultivation and Weed Control	Halem	AN 31	1960

*Effect of nitrogen with and without liming

CACHAR, ASSAM

Project	Site	Index	Year of starting
Rehabilitation of land	Koomber	C 25	1964
N. P. K. Manuring	Isa Bheel	C 26	1966
	Hattikhira	C 27	1966
	Longai	C 28	1966
Nitrogenous fertilizer	Pallorbund	C 29	1966
	Dewan	C 30	1966
Pruning	Pallorbund	C 33	1967
	Dewan	C 34	1967
	Derby	C 35	1968

Project	Site	Index	Year of starting
Shade and Manuring	Koomber	C 36	1968
Soil Climatological Survey	Coombergram	C 20	1962
High Potash Application	Sibuttar	—	1967
	Sahebtillah	—	1967
	Chandkhira	—	1967
	Longai	—	1967
Single Repeat NPK	Burnie Braes	—	1967
	Serispore	—	1967

DOOARS AND TERAI, WEST BENGAL

Project	Site	Index	Year of starting
Rehabilitation of land	Bhogotpore	D 27	1964
	Grassmore	D 28	1964
Nitrogenous fertilizer	Baradighi	D 33	1966
Pruning	Chuapara	D 2	1955
	Baradighi	D 4	1959
	Sam Sing	D 34	1966
Irrigation	Gopalpur	D 35	1966
	Ranicherra	D 36	1968
	Rajabhat	D 32	1968
	Tirrihannah	T R 1	1968
Cultivation and Weed Control	Chuapara	D 42	1970
Soil Climatological Survey	Nya Sylee	D 24	1962
Shade	Nya Sylee	D 9	1958
Infilling	Kartick	—	1969
	Jainti	—	1969
	Fagu	—	1969
	Hilla	—	1969
	Dem Dima	—	1969
	Sahabad	—	1969
	Mohurgong & Gulma	—	1969
High Potash Application	Dalgaon	—	1967
	Rungamuttee	—	1967

DARJEELING, WEST BENGAL

Project	Site	Index	Year of starting
N. P. K. Manuring	Tumsong	DJ 22	1965
	Sungma	DJ 23	1965
Nitrogenous Fertilizer	Lingia	DJ 29	1967
Pruning	Lingia	DJ 21	1963
	Phoobsering	DJ 24	1965
	Goomtee	DJ 25	1966
	Margaret's Hope	DJ 27	1966
Plucking	Mim	DJ18	1961
Soil Climatological Survey	Nagri Farm	DJ 19	1961
High Potash Application	Kumlai	—	1967
	Marybong	—	1967

Appendix - B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES

By

THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Trial of biclonal seed stock	South bank, Assam	Hapjan	AS 200	1963
2.	,,	,,	Tengpani	AS 201	1963
3.	,,	,,	Tengpani		1965
4.	,,	,,	Kakajan	AS 206	1966
5.	,,	North Bank, Assam	Nahorani	AN 202	1963
6.	,,	,,	Sonabheel	AN 203	1964
7.	,,	,,	Durrung	AN 204	1965
8.	,,	,,	Bhooteachang	AN 205	1965
9.	,,	Cachar, Assam	Jellalpore	C 200	1963
10.	,,	,,	Dewan Group of Estates	C 201	1966
11.	,,	Dooars, West Bengal	Sathkyah	D 200	1962
12.	,,	,,	Bhatkawa	D 201	1962
13.	,,	,,	Bhatkawa	D 206	1965
14.	,,	,,	Hantapara	D 202	1964
15.	,,	,,	Meenglas	D 203	1964
16.	,,	,,	Hasimara	D 204	1964
17.	,,	,,	Rydak	D 205	1965
18.	,,	Terai, West Bengal	Hansqua	TR 200	1968
19.	,,	Darjeeling, West Bengal	Mim	DJ 200	1961
20.	,,	,,	Ging	DJ 201	1965
21.	Effect of shade and nutrients	South Bank, Assam	Murmuria	AS 207	1965
22.	Observation plots of biclonal progensies	South Bank, Assam	Bazaloni		1962
23.	,,	,,	Abhoyjan		1969
24.	,,	,,	Duklingia		1963
25.	,,	North Bank, Assam	Nonaipara		1966
26.	,,	,,	Budlapara		1967
27.	,,	Cachar, Assam	Chandighat		1969
28.	,,	Terai, West Bengal	New Chumta		1963
29.	,,	Dooars, West Bengal	Meenglas		1968
30.	,,	Darjeeling, West Bengal	Chongtong		1969
31.	,,	Sikkim	Kewzing		1969
32.	Plucking experiment	South Bank, Assam	Duklingia	AS 208	1971

ENTOMOLOGY DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Directional distribution of scarlet mite	Darjeeling, West Bengal	Balasun	N 7	1968
2.	Abundance of scarlet mite on pruned and skiffed tea	-do-	-do-	N 7	,,
3.	Distribution of scarlet mite under shaded condition	-do-	Ging	N 7	,,
4.	Seasonal cycle of scarlet mite on large leafed and china hybrid bushes	-do-	Chongtong	N 7	,,
5.	Altitudinal distribution of scarlet mite	-do-	-do-	N 7	1970
6.	Red spider distribution on untouched tea on teela	Cachar, Assam	Derby	N 7	1968
7.	Seasonal cycle of red spider on pruned teas on teela	-do-	Serispore	N 7	,,
8.	Seasonal cycle of red spider on skiffed teas on teelas	do-	Acnakhal	N 7	,,
9.	Incidence of scarlet mite in poor and well drained areas	South Bank, Assam	Bokahola	N 7	1967
10.	Distribution of scarlet mite on pruned, skiffed, young and mature teas	-do-	-do-	N 7	,,
11.	Seasonal incidence of shade tree nursery pests	-do	Duklingia	N 8	1970
12.	-do-	-do-	Sycotta	N 8	,,
13.	Seasonal variation in the canker of shade tree	-do-	Bokahola and Sycotta	N 88	1968
14.	Effect of weedicide on the incidence of red spider	-do-	Sotai	N 8	1969
15.	Weedicide effect on distribution of mites	-do	Katonibari	N 8	1970
16.	Termite activity following weedicide application	-do-	Doyang	N 8	1970

	Experiments	Location of Estates	Site (T.E.)	Index No.	Year started
17.	Shade and manure effect on the ecology of mites	South Bank, Assam	Murmuria	N 8	1966
18.	Population cycle of red borer	North Bank, Assam	Arun	N 7	1970
19.	Distribution of scarlet mite under different agricultural operations	Dooars, West Bengal	Ranicherra	N 7	1968
20.	Incidence of scarlet mite on pruned and and skiffed teas	-do-	Telepara	N 7	1968
21.	Clonal susceptibility of red spider	-do-	Nagrakata	N 7	1969
22.	Seasonal cycle of scarlet mite on dark and and light leaf jats	-do-	Kalchini*	N 7	1968

* Experiment continued as long as the estate was member of Tea Research Association

MYCOLOGY DEPARTMENT

	Experiment	Location of Estates	Site (T.E.)	Index No.	Year started
1.	Screening of chemicals against Red rust	South Bank, Assam	Behora	MR 006	1970
2.	Spraying lower dosage of Blitox against Red rust (a) with Power sprayer	,,	Kakajan	MR 005 (A)	1970
	(b) with hand operated sprayer	,,	Behora	MR 005 (B)	1970
3.	Screening of chemicals against Black rot	,,	Dirok	MR 005	1970
4.	Spraying with power spraying with Blitox in different volumes of water against Black rot	,,	Namdang	MB 006	1970
5.	Comparision between the spraying efficiency of a Power sprayer against black rot	North Bank, Assam	Ghoirallie	MB 002	1968
6.	Effect of Potash manuring (collaboration: West Bengal Advisory Dept.) on control of Black rot	Dooars, West Bengal	Baradighi	MB 003	1967
7.	Effect of NPK manuring and shade (collaboration: Botany Dept.) on Black rot, Red rust and *Poria*	South Bank, Assam	Murmuria	BAS 204 MBRC	1966

	Experiment	Location of Estate	Site (T.E)	Index No.	Year started
8.	NPK manuring and its effect on incidence of Thorny stem blight (collaboration: Darjeeling Advisory Branch)	Darjeeling, West Bengal	Sungma	MC 002	1966
9.	Screening of fungicide against Thorny stem blight	Darjeeling, West Bengal	Happy Vally	MC 001	1965
10.	Application of a systemic fungicide against Thorny stem blight	,,	Balasun	MC 003	1970
11.	Control trial with different fungicide against Purple root rot	North Bank, Assam	Baghmari	MP 001	1965

PESTICIDE DEPARTMENT

	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Scarlet mite prophylactic	South Bank, Assam	Deha	—	1970
2.	Purple mite	-do-	-do-	—	1970
3.	Red spider palliative	-do-	-do-	—	1970
4.	-do-	-do-	Katonibari	—	1970
5.	-do-	-do-	Sycotta	—	1970
6.	Scarlet mite palliative	Darjeeling	Singbuli (Tingling)	—	1970
7.	-do-	-do-	Balasun	—	1970
8.	Jassid	South Bank, Assam	Borbhetta	—	1970
9.	Joint action for control of scarlet mite, scales and thrips	Darjeeling	Springside	—	1970
10.	Joint action for control of Red spider, scarlet purple mites.	-do-	Chongtong	—	1970
11.	Cockchafer	Dooars	Dam Dim	—	1970
12.	Red rust	South Bank, Assam	Sycotta	—	1970
13.	Black rot	-do-	Hunwal (Nagrdhoolie)	—	1970
14.	Red spider prophylactic	-do-	Dooria	—	1971
15.	-do-	do-	Sycotta	—	1971
16.	Prophylactic for control of pink, scarlet and purple mites	-do-	Pabhojan	—	1971

STATISTICS DEPARTMENT

	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Uniformity trial	South Bank, Assam	Bokahola Assam	—	1963
2.	Uniformity trial	Darjeeling, West Bengal	Nagri Farm	—	1964
3	Long term defoliation experiment	Dooars, West Bengal	Naya Sylee	—	1963
			Bhogotpor	—	1963
			Jiti	—	1963
			Hope	—	1963
			Kurti	—	1963

ENGINEERING DEVELOPMENT DEPARTMENT

	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Continuous fermenting Machine	South Bank, Assam	Sycotta	E.3	1969 upto Oct. 1970
			Beesakopie		Oct. 1970
2.	Barbora Leaf conditioner	-do-	Powai	E. 2	June 1970
3.	20" T. C. R.	-do-	Heeleakah	E.2	May 1969
4.	Vertical Roller	Dooars	Gandrapa	E.2	May 1968
5.	30" Disc Roller	Darjeeling	Ging	E.2	Oct. 1969
6.	48" Disc Roller	North Bank, Assam	Naharani	E 2	Sept. 1969
7.	Manual Plucking Aid	Darjeeling	Rungli-Rungliot	E.8	1968
		South Bank, Assam	Borbhetta		1968

Appendix - C

Published papers and papers in the Press

1. Banerjee, B. 1971. Aggregating behaviour of the caterpillars of *Andraca bipunctata* Wlk (Bombycidae Lepidoptera). *Sci. & Cult.* 36: 236–239.

(Abs. Diurnal rhythms exist in the feeding and formations of aggregation by the caterpillars of *Andraca bipunctata* Wlk. Aggregations are formed only by the 3rd, 4th and 5th instar caterpillars during the day. After dark the aggregations break up and the caterpillars start feeding on tea leaves. The kinetics and stimuli of aggregations are discussed.)

2. Banerjee, B. 1971. Time series in biological rhythm. *Curr. Sci.* 40:63-64.

(Abs. A mathematical analysis is made of the diurnal feeding rhythms with observations in blocks of time. The appropriate correction factors are obtained by angular transformation of the basic data.)

3. Banerjee, B. 1970. Effects of unmixed and mixed leaf litter of three species of plants on the development and growth of *Polydesmus angustus* Latzel. *Experientia.* 26:1403.

(Abs. For a soil arthropod unmixed litter is conducive to the quick development of generations and production of larger adults: mixed litter produces just the opposite results. The significance of these findings in the bioenergetics of an open ecosystem is discussed.)

4. Banerjee, B. 1971. Dynamics of termite populations—some theoretical considerations. *Insectes, Sociaux.* 18:21-28.

(Abs. Deterministic mathematical models are suggested for the growth and seasonal fluctuations of termite populations. Several hypotheses on the population regulation mechanism of insects are examined with reference to termite populations. It is suggested that a homeostatic mechanism regulates the termite numbers.)

5. Banerjee, B. 1971. Tea pest control strategies in North-East India. *Pl. Chr. XLVIII:* 8-10.

(Abs. The need for stabilizing pest numbers below or at tolerable levels for plants is emphasized. It is discussed that the future of pest control will depend a lot on our abilities to refine and develop techniques of pest management)

6. Barua, G. C. S. & Barua, K. C. (1969). Notes on fungi from North East India: XXV—An undescribed *Cercospora* causing leaf spot of *Indigofera teysmanii* Miq. *Science and Culture.* Vol **35**, No. 9, pp. 487-489.

(Abs. A hitherto unrecorded fungus causing leaf spot disease of *Indigofera teysmanii* Miq. is described as *Cercospora teysmanii* G. C. S. Barua *et* K. C. Barua. The description of the fungus with its latin renderings together with the disease symptoms produced on the host plant are incorporated.)

7. Barua, D. N. A Review of Light as a Factor in the Metabolism of the Tea Plant (*Camellia sinensis* L.). '*Physiology of Tree Crops*', pp. 307-322, Ed. L. C. Luckwill & C. V. Cuttings, Academic Press London and New York, 1970.

(Abs. This review first emphasises the extremely heterogenous nature of the cultivated tea crop and cautions researchers on tea to relate their findings to the experimental material. Short historical background on the use of shade trees in tea plantations and the benefits derived from shade trees in N. E. India are then described. The differences of opinion on the benefits of shade trees expressed in recent years by tea scientists of different countries and the series of experiments carried out at Tocklai on the problem of shade in tea are discussed. These fundamental experiments have shown that the net production of dry matter by the tea bush is reduced at leaf temperatures higher than 35°C. When the ambient temperature is

30° C or above, temperature of exposed tea leaves rises above 35°C, but shaded leaves remain much cooler, at or near the ambient temperature. Thus shade trees can exert beneficial influence on the growth of tea bushes in areas where ambient temperatures rise above 30°C.

The top of the canopy of tea bushes having flat (horizontal) leaves absorbs more radiations and suffer more damage from exposure than bushes with erect or semi-erect leaves, which reflect a fraction of the incident radiation to the lower parts of the canopy. Shading therefore is more beneficial to flat-leafed bushes, although it further reduces the dry matter production by the lower leaves of the bush canopy by limiting the supply of photosynthetic radiation.

Under light shade, a larger fraction of the assimilates is diverted towards the production of shoots which are used for tea manufacture (economic yield), than in full sun. This commercially desirable growth partition appears to be influenced by internal growth regulators. It is suggested that the next stages in the investigation of the shade problem would lead to a study of the auxins, particularly those known to be light-dependent.)

8. Barua, P. K. Flowering Habit and Vegetative Behaviour in Tea (*Camellia sinensis* L.)Seed Trees in North East India. *Ann. Bot.*, 34, 721-35, 1970.

(Abs. Apical growth of a tea shoot occurs by a succession of flushes separated by short periods of rest. This paper describes the external morphology of flowering, fruiting and abscission of leaves of the tea plant in north-east India in relation to the phasic activity of shoot apices.

All shoots on a tree make leafy growth when a new cycle of growth begins in the spring, but terminal buds apparently become dormant as the season advances. Apparently dormant terminal buds shed bud scales, leaving on the stem a considerable number of scars, representing leafless cataphyllary flushes. These cataphyllary flushes are produced at the same time as the leafy flushes on other shoots.

A flower is formed only in the axil of a bud scale. Flowers which appear to develop in leaf axils are in fact inserted in the axils of bud scales of the axillary buds.

A distal leafy flush is without flowers. Flowers appear in its leaf axils only when the terminal bud starts growth for the next higher flush. A distal floriferous cataphyllary flush appears as a terminal cluster of flowers. Thus, there is an acropetal succession of flowers, flush by flush on a caulome, determined by the phasic activity of the apical bud.

The main crop of flowers exposes anthers from the end of the third flush (late September to early October) until the end of the winter period of growth late January to early February). In some plants a second, minor crop of flowers appears in the spring between the end of the first and beginning of the second flushes. In spite of considerable time lag between anthesis, the fruits produced by these two crops of flowers mature and dehisce at the same time during October to November.

Abscission of leaves is also dependent upon the phasic activity of the apical buds. Only the top two flushes of a shoot possess leaves. Resumption of a pical growth for a third flush, leafy or cataphyllary, causes the abscission of leaves on the lowermost of the three flushes. Two cataphyllary flushes therefore result in the loss of all leaves on a shoot.)

9. Choudhury, R., co-authors Deb, S.B. and Choudhury, M. N. D. (1971). Tea as vehicle for lysine fortification, *Protein Fortification of Food*, Association of Food Technologists Eastern Regional Branch (India) pp 78-79.

(Abs. Addition of lysine during the process of tea manufacture does not affect the taste or valuation significantly, a tea drinker would not perceive the difference between the treated teas and teas without treatment. If teas for internal market are to be fortified with lysine without affecting the export market, the finer teas are sifted and exported, the remainder may be treated with lysine using a sprayer above the conveyor belt, which will not involve any major engineering expenditure, only the cost of lysine will be extra expenses. If in India, the total requirement of lysine is to be met through tea per capita consumption of tea will have to be increased 11 times and lysine needed about 134 million kg per year. However if a fraction of lysine is to be met through tea specially to the poor section of people, tea can be drunk twice a day with their meals and it can effectively be used as a vehicle for lysine fortification.)

10. Deb, S.B. and Choudhury, M.N.D; co-authors Choudhury, R. and Barua, B. N. (1971) Fortifying tea with lysine-hydrochloride *Protein Fortification of Food*, Association of Food Technologists Eastern Regional Branch (India) pp 74-77.

(Abs. It has been demonstrated by small scale manufacturing experiments that tea can be fortified with lysine. 160 mg of lysine per cup of tea can be obtained by spraying aqueous lysine hydrochloride over leaves during the C.T.C. manufacturing process and over 80 per cent of the incorporated lysine can be recovered in the tea liquor. The extra cost of fortifying a cup of tea will be one third of a paisa and the daily adult requirement of lysine can be met by about 4 or 5 cups of such fortified tea. It is suggested that only teas sold for internal consumption should be fortified.)

11. Banerjee, B. Oviposition and eclosion rhythms in *Andraca bipunctata* Wlk (Bombycidea : Lepidoptera). *Indian J. Ent.* (In the press)

12. Banerjee, B. Theoretical models on predator-prey relationships in arthropods. *Proc. Zool. Soc.* (In the press)

13. Banerjee, B. Population dynmics of *Andraca bipunctata* Wlk (Bombycidae: Lepidoptera). *J. appl. Ecol.* (Communicated)

Appendix—D

Summary of meteorological observations during 1970

Table 1. Tocklai (Mid Assam)

Latitude: 26° 47′N Longitude: 94° 12′E Altitude: 86.6 metres a.m.s. l.

Month 1970	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth				
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	21.6 (22.4)	9.5 (9.2)	15.5 (15.8)	24.4	5.9	50.0 (21.1)	9 (5)	6.3 (5.8)	17.8 (18.9)	17.5 (18.3)	18.5 (19.0)	37.4	58.9
February	23.9 (24.1)	11.8 (11.8)	17.8 (18.0)	27.1	8.5	47.5 (32.1)	8 (7)	7.2 (6.1)	19.9 (20.7)	19.4 (19.8)	19.8 (20.2)	52.9	81.5
March	27.0 (27.5)	16.3 (15.4)	21.6 (21.5)	31.8	14.4	81.9 (82.6)	10 (11)	6.9 (6.6)	24.0 (24.1)	23.2 (23.0)	23.2 (23.0)	92.8	125.8
April	28.8 (28.7)	19.4 (18.9)	24.1 (23.8)	32.7	14.2	140.1 (190.7)	11 (17)	6.4 (5.9)	26.6 (27.0)	25.7 (25.8)	25.6 (25.6)	101.9	142.2
May	28.9 (29.9)	22.4 (21.7)	25.6 (25.8)	33.8	20.0	372.7 (283.0)	17 (20)	5.3 (5.0)	28.4 (28.6)	27.6 (27.6)	27.5 (27.6)	97.0	150.8
June	30.8 (31.5)	24.9 (24.1)	27.8 (27.8)	35.7	22.5	354.9 (323.9)	25 (23)	3.9 (4.4)	30.5 (30.6)	29.6 (29.5)	29.6 (29.3)	91.6	148.1
July	31.7 (32.2)	25.4 (24.5)	28.6 (28.4)	35.3	24.4	353.5 (386.3)	25 (25)	3.5 (4.8)	31.4 (31.4)	30.4 (30.4)	30.4 (30.4)	81.6	143.2
August	31.6 (32.0)	25.3 (24.5)	28.4 (28.3)	34.7	23.0	355.3 (338.7)	21 (23)	4.7 (5.0)	31.4 (31.4)	30.6 (30.5)	30.6 (30.4)	85.1	149.8
September	31.2 (31.2)	24.7 (23.8)	28.0 (27.5)	34.3	23.1	224.0 (254.9)	20 (19)	4.3 (5.0)	30.2 (31.0)	29.9 (30.2)	30.0 (30.2)	79.3	125.4
October	28.6 (29.3)	21.5 (20.9)	25.0 (25.1)	31.7	19.9	151.1 (115.5)	10 (12)	6.1 (5.6)	26.9 (28.5)	27.1 (28.0)	27.4 (28.2)	60.0	115.4
November	26.8 (26.2)	16.0 (15.1)	21.4 (20.6)	29.8	10.3	27.1 (26.9)	4 (4)	6.8 (6.1)	23.4 (24.1)	23.8 (23.6)	24.6 (24.6)	50.3	84.1
December	24.1 (23.4)	10.1 (10.6)	17.1 (17.0)	25.3	8.0	0.0 (10.3)	0 (3)	7.1 (5.9)	18.5 (20.1)	18.8 (19.8)	20.0 (20.8)	36.3	61.8

Note: (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Per cent Relative humidity

Table 1 (a) Tocklai

Hours of observations I. S. T.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 13	95 (97)	94 (95)	91 (93)	90 (91)	91 (93)	92 (93)	92 (93)	93 (94)	93 (95)	95 (97)	95 (97)	95 (97)
13 13	57 (58)	53 (55)	52 (54)	61 (62)	73 (71)	77 (75)	76 (75)	77 (75)	76 (74)	73 (72)	60 (64)	54 (61)

Note:—Data in brackets show previous averages

Summary of meteorological observations during 1970

Table 2. Silcoorie (Cachar)

Latitude: 24° 50'N Longitude: 92° 48' E Altitude: 39.6 metres a. m. s. l.

Month 1970	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
										Depth		Open pan in mm	Penman in mm
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm		
January	24.6 (26.0)	10.3 (20.9)	17.4 (18.4)	27.1	8.1	43.2 (20.6)	4 (2)	7.8 (8.0)	20.2 (21.4)	19.6 (20.7)	20.4 (21.4)	57.2	75.8
February	27.3 (27.4)	13.1 (12.7)	20.2 (20.0)	30.6	8.6	121.3 (46.6)	7 (4)	8.4 (8.0)	22.6 (23.4)	21.4 (22.2)	21.7 (22.4)	75.0	102.4
March	30.4 (30.6)	17.4 (16.5)	23.9 (23.6)	34.5	15.0	222.4 (104.3)	7 (8)	7.1 (7.9)	26.6 (26.8)	25.4 (25.4)	25.2 (25.4)	120.3	142.1
April	31.1 (32.3)	21.3 (20.5)	26.2 (26.4)	34.8	17.5	292.7 (219.6)	16 (12)	7.2 (7.8)	28.8 (29.7)	27.3 (28.2)	27.0 (28.1)	114.1	160.4
May	32.6 (31.9)	23.4 (22.8)	28.0 (27.4)	36.3	20.6	176.0 (398.8)	11 (19)	7.1 (6.5)	31.2 (30.6)	29.8 (29.4)	29.6 (29.3)	121.9	183.7
June	32.4 (31.5)	25.0 (24.4)	28.7 (28.0)	37.6	22.8	424.0 (610.9)	23 (24)	4.6 (4.0)	31.4 (30.5)	30.3 (29.6)	30.2 (29.4)	124.1	152.5
July	31.2 (32.2)	25.0 (25.0)	28.1 (28.6)	36.3	22.8	586.6 (538.5)	28 (27)	3.5 (4.5)	30.8 (31.4)	30.2 (30.5)	30.2 (30.4)	88.7	139.7
August	32.6 (32.1)	25.1 (24.9)	28.8 (28.5)	35.3	23.9	546.4 (428.4)	24 (25)	5.2 (4.8)	32.0 (31.4)	31.0 (30.6)	30.8 (30.6)	119.0	157.8
September	31.8 (32.4)	24.5 (24.6)	28.2 (28.5)	34.6	23.1	667.4 (327.4)	21 (17)	4.6 (5.7)	31.2 (31.2)	30.4 (30.4)	31.0 (30.4)	104.4	132.7
October	30.4 (31.2)	22.6 (22.3)	26.5 (26.8)	33.8	19.9	314.4 (208.8)	16 (10)	5.5 (6.6)	29.2 (29.4)	28.6 (28.8)	29.0 (29.0)	85.3	120.8
November	28.9 (29.3)	17.4 (17.0)	23.2 (23.1)	32.6	12.7	36.6 (16.3)	5 (2)	7.3 (8.0)	25.4 (25.9)	25.2 (25.5)	26.0 (26.0)	71.2	93.3
December	27.0 (27.0)	12.4 (12.6)	19.7 (19.8)	29.5	9.4	0.0 (8.2)	0 (1)	8.5 (7.9)	22.6 (22.7)	22.2 (22.4)	23.4 (23.0)	63.2	82.2

Note : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface

Per cent Relative humidity

Table. 2(a) Silcoorie

Hours of observations I. S. T.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 19	99 (98)	99 (96)	95 (93)	92 (90)	89 (91)	95 (95)	96 (95)	97 (95)	96 (95)	96 (97)	97 (97)	98 (98)
13 19	51 (46)	49 (43)	49 (43)	61 (54)	66 (67)	73 (76)	80 (75)	74 (74)	75 (71)	71 (67)	56 (55)	47 (48)

Note : Data in brackets show previous averages

Summary of meteorological observations during 1970

Table 3. Nagrakata (Dooars)

Latitude: 26° 54′ N Longitude: 88° 55′ E Altitude: 228.6 metres a.m.s. l.

Month 1970	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth			Open pan in mm	Penman in mm
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm		
January	22.8	9.4	16.1	24.1	7.3	11.8	5	7.0	17.8	18.6	19.6	67.0	67.9
	(23.7)	(10.4)	(17.0)			(12.9)	(2)	(8.1)	(18.0)	(18.0)	(19.4)		
February	25.0	11.3	18.2	28.0	6.8	26.6	4	7.7	19.8	19.9	20.6	93.6	90.2
	(25.7)	(13.1)	(19.4)			(20.3)	(3)	(7.7)	(20.2)	(19.7)	(20.6)		
March	28.7	15.6	22.2	33.0	10.1	13.4	5	7.7	24.0	23.8	23.8	147.8	136.6
	(29.2)	(16.3)	(22.8)			(52.6)	(6)	(7.7)	(23.8)	(23.2)	(23.6)		
April	31.0	20.0	25.5	33.7	13.8	231.6	15	6.8	27.0	26.8	26.6	167.6	145.1
	(31.4)	(20.0)	(25.7)			(107.0)	(10)	(7.4)	(27.0)	(26.2)	(26.5)		
May	31.2	22.4	26.8	34.4	19.5	359.1	17	6.9	29.0	28.2	28.4	145.9	175.2
	(31.0)	(21.6)	(26.3)			(298.2)	(20)	(6.7)	(28.4)	(27.6)	(28.0)		
June	30.1	23.7	26.9	33.3	21.5	1,018.7	28	3.7	28.6	27.9	28.2	87.0	133.9
	(30.5)	(23.3)	(26.9)			(882.1)	(26)	(3.8)	(28.6)	(28.0)	(28.4)		
July	30.3	24.1	27.2	33.4	22.1	1,287.2	28	2.9	28.7	28.8	28.8	93.0	126.1
	(30.4)	(23.8)	(27.1)			(1,028.2)	(27)	(3.5)	(29.1)	(28.3)	(28.6)		
August	31.3	24.2	27.8	35.0	22.9	775.4	26	4.8	29.2	28.4	29.4	114.7	151.8
	(30.5)	(23.7)	(27.1)			(773.0)	(28)	(4.0)	(29.3)	(28.7)	(29.0)		
September	30.1	23.4	26.8	34.4	21.0	920.8	23	4.4	28.6	28.4	29.0	107.4	120.5
	(30.6)	(22.8)	(26.7)			(521.5)	(21)	(5.3)	(28.9)	(28.8)	(28.8)		
October	29.9	19.8	24.8	31.8	15.3	74.5	8	8.3	27.2	27.4	27.4	105.5	134.8
	(29.8)	(19.2)	(24.5)			(183.8)	(10)	(8.0)	(26.8)	(27.2)	(27.2)		
November	27.9	14.3	21.1	30.5	10.5	3.1	1	9.5	23.0	23.6	24.7	97.0	100.1
	(27.2)	(14.6)	(20.9)			(13.0)	(3)	(8.5)	(22.5)	(22.8)	(24.3)		
December	25.3	10.9	18.1	27.0	8.5	0.0	0	8.8	19.5	20.2	21.3	78.4	75.2
	(24.9)	(11.6)	(18.2)			(3.8)	(1)	(8.4)	(19.6)	(19.9)	(21.1)		

Note : (i) Date in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface

Per cent Relative humidity

Table 3. (a) Nagrakata

Hours of observations I. S. T.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 34	89	86	80	77	85	96	97	94	97	88	98	84
	(83)	(80)	(75)	(75)	(86)	(95)	(96)	(96)	(95)	(88)	(84)	(86)
13 34	52	48	50	48	69	82	84	82	83	62	53	44
	(51)	(50)	(47)	(52)	(70)	(82)	(84)	(82)	(78)	(66)	(58)	(54)

Note : Data in brackets show previous averages.

Summary of meteorological observations during 197

Table 4. Nagri Farm (Darjeeling)

Latitude: 26°55'N Longitude: 88° 12'E Altitude: 1158.2 metres a. m. s. l.

Month 1970	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth			Open pan in mm	Penman in mm
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm		
January	14.4	7.3	10.8	18.5	5.2	14.3	6	5.5	13.0	12.0	14.0	36.9	52.8
	(15.3)	(7.8)	(11.6)			(19.9)	(3)	(6.5)	(13.1)	(12.5)	(14.0)		
February	17.3	9.4	13.4	20.0	6.6	22.6	4	6.5	15.1	13.2	14.8	55.1	76.2
	(16.8)	(9.6)	(13.2)			(16.9)	(3)	(6.1)	(14.8)	(13.8)	(14.6)		
March	21.2	13.2	17.2	25.9	7.8	9.1	3	7.2	19.6	17.0	18.1	103.7	124.0
	(20.7)	(12.8)	(16.8)			(65.6)	(5)	(6.7)	(18.7)	(17.2)	(17.4)		
April	25.1	16.6	20.8	28.8	14.0	42.8	9	5.9	23.5	21.2	21.7	112.0	142.3
	(23.5)	(15.8)	(19.6)			(78.0)	(9)	(6.0)	(21.8)	(20.2)	(20.2)		
May	25.3	18.0	21.6	28.1	15.9	168.0	19	5.8	23.9	22.3	22.8	91.9	144.3
	(23.8)	(17.2)	(20.5)			(204.4)	(18)	(5.3)	(23.6)	(22.1)	(22.0)		
June	24.4	19.0	21.7	26.9	17.5	564.2	29	2.2	24.2	22.3	23.2	48.0	109.3
	(24.0)	(18.8)	(21.4)			(404.9)	(25)	(3.1)	(24.6)	(23.4)	(25.2)		
July	24.9	19.2	22.0	27.9	17.5	787.1	29	1.8	25.6	23.6	24.3	62.0	102.4
	(24.0)	(19.4)	(21.7)			(661.9)	(27)	(2.4)	(24.8)	(23.6)	(23.8)		
August	25.8	19.3	22.6	30.8	18.1	370.6	27	3.3	26.4	24.3	25.1	62.0	117.3
	(24.5)	(19.1)	(21.8)			(490.5)	(26)	(3.1)	(25.1)	(24.0)	(24.2)		
September	24.9	18.7	21.8	29.4	17.2	325.6	25	3.7	25.2	23.4	24.6	55.1	104.9
	(24.3)	(18.3)	(21.3)			(308.1)	(20)	(4.1)	(24.2)	(23.4)	(23.6)		
October	24.4	16.5	20.4	26.4	13.7	31.1	7	7.5	24.1	22.0	23.2	84.0	115.9
	(23.0)	(15.4)	(19.2)			(138.7)	(7)	(6.9)	(21.9)	(21.0)	(21.6)		
November	22.7	12.3	17.5	25.4	9.1	1.3	1	8.3	19.9	18.0	20.3	67.6	86.5
	(19.8)	(11.6)	(15.7)			(12.4)	(2)	(7.0)	(17.8)	(17.2)	(18.6)		
December	18.7	9.6	14.2	22.6	7.9	0.0	0	7.2	15.5	14.0	16.5	53.6	63.4
	(17.5)	(9.2)	(13.4)			(3.0)	(2)	(6.9)	(14.7)	(14.2)	(15.7)		

Note : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface

Per cent Relative humidity

Table 4. (a) Nagri Farm

Hours of observations I. S.T.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
06 37	72	69	63	65	78	92	93	90	89	73	63	65
	(70)	(70)	(65)	(67)	(80)	(92)	(94)	(95)	(89)	(76)	(69)	(71)
13 37	70	57	56	63	78	90	85	86	86	72	63	65
	(69)	(66)	(62)	(67)	(82)	(89)	(88)	(88)	(83)	(80)	(74)	(72)

Note : Data in brackets show previous averages